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CONTENTS:

	PAGE
The *Lancet* on Welsbach Lights	57
A Mercury Switch for Lecture Table Use (*illustrated*)	60
The Working of Electric Tramways in France	60
Smoke Prevention and Elliott's Patent	61
On a Magnetometer for Showing the Influence of Temperature on the Magnetisation of Iron and Other Magnetic Substances (*illustrated*)	63
On the Price of the Ozone	64
Aluminium *v.* Steel	65
The Methods of Resuscitating Victims after Electrical Accidents	65
The Walker-Wilkins Voltaic Battery (*illustrated*)	66
The Arc Lamp	68
Tunbridge Wells *en fête*	69
The Cost of Working Portsmouth Electricity Works (*illustrated*)	69
The Heating Power of Smoke	70
Proceedings of Societies:—	
The Institution of Electrical Engineers	71
The Northern Society of Electrical Engineers	72
Correspondence:—Muirhead *v.* Commercial Cable Company	73
Are Birds on the Wing ever Killed by Lightning?	74
The Incandescent Gas Light	74
Higher Voltage Lamps for Central Stations	74
The Design of Large Alternators	75
Edison Phonograph Motor.—Resistance Alloys	75
Explosions and Means of Remedying (*illustrated*)	75
Explosions in Electric Culverts	75
Primary Batteries (*illus.*).—Submarine Cable Grapnels	76
Young Engineers	76
Muirhead *v.* Commercial Cable Company	77
Cutting through the Pole-pieces of Dynamos	77
Notes	78
Business Notices, &c.	80
Contracts Open and Closed	82
City Notes	82
Traffic Receipts	82
Share List of Electrical Companies	83
Electric Discharge Through Gases (*illustrated*)	84
Inquiry by the Board of Trade into the St. Pancras Explosion	86
New Patents.—Abstracts of Published Specifications	88

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THE "LANCET" ON WELSBACH LIGHTS.

A SCIENTIFIC report, whether made by an expert, or by a commission, is very properly expected to be strictly accurate in its conclusions, precise in its methods, and the tests applied to ascertain the facts ought to be above suspicion; and for that reason they are usually very minutely detailed in a report.

A *Lancet* Commission has just issued a report on incandescent gas lights, a copy of which we have before us. In many respects it is unsatisfactory and disappointing, and we fail to find any support in the report itself, for the expressed admiration for this form of lighting, and the laudatory terms therein contained regarding incandescent lighting by gas are somewhat incomprehensible in the face of the figures given.

This remarkable production of the *Lancet* Commission begins with a long and altogether superfluous notice of the early history of gas lighting, and the subsequent discoveries of valuable products in the tar residue. Then follows a brief history of incandescent gas lighting, mentioning, by the way, and recalling the fact, that there have been many previous attempts to introduce this kind of illuminant. We have seen the "Clamond," "Lewis," "Sellon" and "Fahnejelm" systems come and go, all of them on the same principle as this last comer. The ideas of the *Lancet* Commission regarding light and heat are somewhat hazy, for they talk of the incandescent mantle converting heat rays into light rays, and say that this system of lighting is "probably the best ever obtained for the conversion of heat into light rays." Yet nowhere in the report can we find the slightest evidence to warrant such an opinion. Welsbach burners consuming 7 cubic feet per hour, we find, from the figures given by the commission, raised the temperature of a room 10·5° in one hour. Batswing (Bray's) burners, burning 12 cubic feet per hour, raised the temperature 15·5° in one hour, so that the Welsbach gave the greatest increase of heat per cubic foot of gas burnt, the ratio being $\frac{10{\cdot}5}{7}$: $\frac{15{\cdot}5}{12}$ = 1·5 for Welsbachs, and 1·3 for common gas burners.

The heat produced per candle-power is given for Welsbach at 0·116°, and for common burners at 0·807°; but the candle-power is doubtful, so that the figures are of but small value. We shall further on consider this question of candle-power.

There can be no mistake, however, about the heat per cubic foot burnt, as the cubic foot measurement is reliable, and so far the common burner, producing less heat, is superior. So much for the heating question; now for the production of $C O_2$.

Here, again, the Welsbach shows to advantage, if we accept the candle-power as the basis of comparison, $\frac{CO_2}{C.P.}$

gives a good result; but, as we shall presently show, it is fallacious.

The significant figures are those giving = the CO_2 increase in the atmosphere per cubic foot of gas burnt; on this basis of comparison, again, the common gas burner is better, for it gives an increase of CO_2 per cubic foot of 4·6, against the Welsbach 4·8.

We think the Commission ought to have given the measurement of the candle-powers of the lights some little attention, considering they lay such stress upon the heat and CO_2 per C.P. The statement that the light of a Welsbach burner is 50 C.P. has been accepted as correct by the Commissioners, but we insist that it should be clearly defined what C.P. is meant, whether mean spherical or maximum? We must also know by what method, and against what standard, the light was tested. The report entirely neglects these most important essentials, and, therefore, the candle-power estimates, and the deductions made from them, are hardly worth consideration.

We have already alluded in our previous article to the errors liable to enter into candle-power measurement of lights having a high luminosity and a low diffusive power, like the incandescent gas light.

Luminosity is of no value, it is diffusive power we want in an illuminant. But, granted that the candle-power is greater per cubic foot burnt in a Welsbach than in a common gas burner, the arguments based upon that fact by the Commission are again fallacious.

The argument that Welsbach burners consuming 7 cubic feet instead of 12, as in the common burners, must necessarily produce less heat and less poisonous gas, only holds good in one case, and that case is not met with in practice. It holds good only if a consumer is content with the same quantity of light and a reduced gas bill. But that is not what the consumer wants, he desires to get the great increase of light promised by the Welsbach burner; this is, indeed, the only reason why he should make the change.

It is obviously impossible to secure both advantages. As the old saying goes, "you cannot eat your cake and have it." The increase of light is got by burning nearly the same quantity of gas in a Welsbach as we do in a common burner. We cannot get this increase of light if we wish to secure the other advantages promised by the *Lancet* Commission, namely, less heat and less CO_2. Indeed, the arguments of the *Lancet* amount to this: that by means of the Welsbach we can vastly increase the light and materially reduce the gas consumption at the same time.

But that is wrong. The fact is we may obtain the same light with less consumption, or more light with the same gas expended, but it is misleading to argue that the great increase of light and the great reduction in gas consumed can both be secured simultaneously.

Another important point not touched upon by the Commissioners of the *Lancet*, is the minimum light practicable with Welsbach mantles. The common size, nominally 50 C.P., we have been informed, is the smallest practicable; that being so, it is evident that consumers must go in for increase of light instead of reduction of gas consumption, for as a rule they do not reduce the number of jets when the new light is adopted.

To secure all the supposed benefits of the sanitary class, so much dwelt upon by the Commissioners, 16, or even 12 candle-power Welsbach lights would be required to replace the common batswing burner, instead of the so-called 50-C.P. light; but the incandescent gas people know only too well that such a small light would be an utter failure with the low diffusive power at their disposal.

We have spoken of the luminosity and diffusive power of an illuminant, and perhaps it would be well to explain the distinction between the two in a physical sense. We may find a light of high luminosity which has a low diffusive power, and *vice versâ*, and perhaps the most familiar analogy can be found in musical sounds; there may be a sound produced of high pitch, but so weak as scarcely to be heard, which corresponds to high luminosity and low diffusive power; and again, a sound of low pitch but of great loudness corresponds to low luminosity but with great diffusive power.

In light, as well as in sound, we must consider amplitude of vibration as well as frequency. Common gas burners and electric incandescent lamps, although producing light of lower frequency, have great diffusive power owing to the greater amplitude of vibration, and this is the reason why a gas light can be seen further through a fog than an arc light. The same effect is easily noted on Welsbach lights in a fog, for they become invisible long before the common gas light is obscured, thus ocularly proving their low diffusive power.

It has now become necessary in measuring lights from different sources to measure diffusive power, instead of simply comparing luminosities as has hitherto been practised, as these comparisons are reliable only when the lights compared are composed of rays, similar in kind and in approximately the same proportional parts. To compare two so entirely different lights as the Welsbach and an electric incandescent lamp is unfair and absurd.

All these important points are passed over in this report of the *Lancet*, and the figures widely advertised by the interested parties are accepted and put forward as if they were carefully ascertained and verified by direct tests. Against this way of examining and reporting on such a simple affair we protest most strongly.

Now we come to the matter of the existence of carbon monoxide in the products of combustion. The Commissioners say that they found no carbon monoxide during an eight hours' test of two Welsbach lights. We are not surprised at this, for the tests were too short in duration, and the blood solution is not the most reliable test for carbon monoxide; as a conclusive test it often fails.

The carbon monoxide is not always a product of the combustion, but is often produced when the mantles become sooty; the hot free carbon then splits up the CO_2 into carbon monoxide. This reaction takes place chiefly at the upper and cooler end of the incandescent mantle.

On the whole, the Commission has failed entirely to prove anything, except that from a sanitary point of view the new light is not much better than a common gas burner, and for the reasons here given we trust that the report will not in any way be taken as authoritative and conclusive.

Complete, thorough, and unbiassed tests would reveal very different facts and figures from those given by the rough, brief, and unsound investigation made by the *Lancet* Commissioners.

Finally, we may quote some measurements and estimates made by Heim, of Hanover (*Lumière Electrique*, Vol. xxvi., page 219). A batswing burner gave 16 C.P. in a horizontal plane, with a consumption of 14·8 litres per hour per candle, and at an inclination of 45° to the horizontal, 17·2 candles with the same consumption.

An Auer-Welsbach gave 14·4 candles in a horizontal plane, and only 10·5 at an inclination of 45°, with a consumption of 9·8 litres per hour per candle in the horizontal plane, the consumption being the same in the 45° plane when giving only 10·5 candles. These figures do not show the same high economy as those given by the promoters of the new light, and accepted by the Commissioners, and prove that only in one plane is the higher luminosity obtained from the incandescent mantle.

At the inclination of 45° the consumption in old and new lights is, according to these estimates, nearly equal per candle-power hour, being, approximately, 13 litres for the Welsbach, and 14 for the batswing gas burner.

The candle-power per cubic foot of gas is the rock upon which the *Lancet* splits; upon its correctness depends the whole value of the conclusions arrived at, yet upon this important point the Commission has no tests to describe nor results to give, yet it ought to have formed the most important determination in the investigation.

Explosions.

THE enquiry into the St. Pancras explosion in electric light mains was not altogether satisfactory. The nature of the explosive, or what fired it, was not definitely established. The conclusion come to was simply an undertaking on the part of the consulting engineer who has been responsible for the laying of the mains on the plan which is so liable to explosion, that he will see that the Vestry do all in their power to prevent the accumulation of gas and water in the conduits. It was his bounden duty to see to this at the very outset; as the consulting engineer, he is responsible for what has happened; both the accumulation of explosives in conduits, and the firing of them, ought, with good engineering, to be impossible. It needed no elaborate investigation to come to the conclusion that something exploded, and that something might be fired by a spark. There must be something distinctly weak about a system in which explosions are liable to occur, and for which no reasonable explanation can be given at a public examination.

The Faure Patent.

NUMEROUS patents made famous in the wild speculative times of 1880 to 1882, have dropped out, and are becoming extinct daily. As they go, one after the other, few people regret their passing, as electrical engineering is being freed from monopoly of any kind. There may be a few detail patents covering modified constructions of battery plates, but the Master Patent of Faure, No. 129, 1881, has now lapsed. Like many other patents, it set out by claiming far too much, so much so, that to save it from destruction, two out of the four claims made were disclaimed, and no less than eleven words struck out of the title; the specification was also cut down to correspond. It strikes us that it is a very common practice to cut down claims in Master Patents, and if this proves anything at all, it shows that "fishing" claims are always put forward with deliberate intent. Master Patents are good things in a way, for by their means capital is forthcoming, and, although it is often squandered, in many cases it promotes a manufacture which would have languished without the financial inducement of a Master Patent promising a monopoly. The Faure patent was not of a revolutionary nature, and much money was invested and lost over it, but it brought out capital enough to carry on secondary battery manufacture, and gave a tremendous impetus to the study and application of these cells. No batteries yet brought out fill the want for a reservoir, like a gas holder, in electrical distribution of energy, and no battery yet invented meets the requirements for electric locomotion. But we feel certain that these problems will soon be solved, and we hope that when another Master Patent is obtained it will not be manipulated in the way of the Faure patent. It is quite proper to use a Master Patent to obtain capital sufficient for the working and purchase of the patent on reasonable terms, but before it can be used to raise enormous sums of money its true commercial value ought to be fully proved; such values cannot be estimated by scientific experts, however eminent.

The Telephonic Measurement of E.M.F.

NOTWITHSTANDING the varied use which has been made of the telephone in electrical measurements, only isolated efforts (*e.g.*, "Ledeboer, Beiblätter," ix., p. 357) have hitherto been made to replace the galvanometer by the the telephone in the zero methods for electromotive force. Yet, according to some of the earlier observers, the telephone ought to be more than sufficient for the purpose. This problem has recently been suggested to Prof. Carl Barus in connection with his well-known studies on thermo-electric pyrometry, where an avoidance of the galvanometer would often facilitate the work. More recently it has again come beneath his notice in relation to certain meteorological experiments in which temperatures are made to vary in rapid rhythm by condensation, and the object is to find the thermal amplitude, and the character of the oscillation. It thus becomes necessary to vary the electric constants in like rhythm, and to find the temperatures for all differences of phase between the two pulsations thermo-electrically by a zero method. Here, therefore, the instantaneous telephonic registry would have advantage over the galvanometer, aiding the ear in somewhat after the manner in which the stroboscope assists the eye. In endeavouring to make the telephone sensitive enough, Prof. Barus experienced unexpected difficulty, and the work resulted in showing that the range of increments of the magnetic field on both sides of zero, within which the telephone does not respond, is out of proportion with the sensitiveness of the instrument. In a paper published in the current (December) issue of the *Philosophical Magazine*, an account is given of an investigation undertaken to find the extent and character of this silent interval in its relations to the method in question. Except for this aim the work of Prof. Barus covers much of the same ground as Lord Rayleigh's recent researches on the same subject. For an account of the apparatus and the methods of obtaining the results, the original paper must be consulted, since it is not suitable for condensation. In endeavouring to account for the occurrence of the silent interval, Prof. Barus hazards a straightforward supposition. He will not admit references to hysteresis, to inconstancy of batteries, &c., but assumes that the interval is to be referred to a molecular inertness of the telephone plate, very similar in its nature to quiescent friction. The diaphragm at rest seems initially to resist further deformation, and this resistance must first be overcome before the telephone will respond with nicety to fine gradations of the actuating stress. In other words, as soon as the internal friction encountered in moving the diaphragm has passed from the quiescent to the kinetic stage, the instrument is ten or more times more sensitive than it was before the critical stress value had been exceeded.

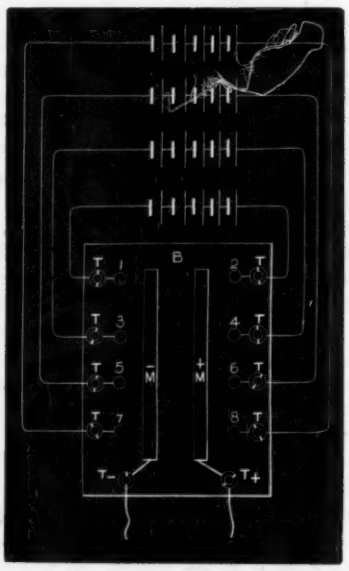
A MERCURY-SWITCH FOR LECTURE TABLE USE.

By W. PERREN MAYCOCK, M.I.E.E.

SPEAKING more particularly with reference to science classes in magnetism and electricity, there are as yet comparatively few with facilities for obtaining current from a dynamo or from the street mains, or even from a secondary battery. In such, a primary battery has to be used; and partly on account of the trouble in setting up the cells, the number required, and ignorance or difficulty of combining them properly for a given effect, there are a good many experiments of great importance that are not shown to the class at all. Among these may be mentioned the magnetic figures of straight and coiled current-carrying conductors, a current-carrying conductor picking up iron filings, the sucking effect of a solenoid, the electric arc, attraction and repulsion of currents, the principle of the electromotor, &c.

The above and many other experiments in current electricity require currents of widely varying strength; and to get the proper current for any given experiment, the battery must be arranged as regards E.M.F. and internal resistance as to suit the conditions of the outside circuit and apparatus. For experiments on the electric arc for instance, all the cells would have to be put in series; while for a good number of other experiments with apparatus having a very low resistance, and requiring a heavy current, the cells must be arranged in some parallel-series combination. In this connection it should be remembered that with a given number of cells, the greatest current is obtained when the cells are so arranged that the internal resistance of the battery is equal to the external resistance.

To facilitate the quick arrangement of cells in various series and parallel-series combinations, the writer has devised the simple and easily constructed form of mercury switch illustrated in the accompanying figure. Not only is much



time saved by the use of this apparatus, but absolutely perfect connection is made between the separate batteries. B is a teak base, 1 inch thick, 6 inches wide, and of a length proportional to the number of batteries it is intended to provide for. The switch illustrated will accommodate four separate batteries, in the present case of five cells each. The batteries may, of course, be composed of any convenient number of cells, but they must all be equal. The batteries are connected with the terminals, T, T, T, &c., as shown, and the latter have thick copper wires riveted to them, the ends of which dip into the mercury cups, 1, 2, 3, &c. T+ and T−, are the terminals to which the outside circuit is connected; these are connected by stout pieces of wire with the mercury troughs, M + and M −.

Suppose all the cells are to be put in series, 1 and M−, 2 and 3, 4 and 5, 6 and 7, 8 and M+ must be respectively connected by bent pieces of thick copper wire: this will give twenty cells in series. If fifteen cells only are required, 1 and M−, 2 and 3, 4 and 5, 6 and M+, must be connected. Similarly, ten or five cells in simple series may be used. Suppose the batteries are all to be thrown in parallel, 1, 3, 5, and 7 are connected by short wires with M−; and 2, 4, 6, and 8 with M+. This will give four parallel rows of five cells in series. If 1 and M−, 2 and 3, 4 and M+, 5 and M−, 6 and 7, 8 and M+ be connected, we shall have two parallel rows of ten cells in series.

When cells are arranged in parallel, it is not well to leave them so connected for any length of time, even though each row be nominally equal in E.M.F. With the above switch, the cells may be thrown in and out of circuit immediately before and after an experiment, without the slightest trouble.

THE WORKING OF ELECTRIC TRAMWAYS IN FRANCE.

THE Direction of Railways at the Department of Public Works has drawn up a table giving the comparative results of the working of French railways, the lines of local interest, and tramways during the first halves of 1893 and 1894.

We (*L'Energie Electrique*) borrow from this table, published in the *Official Journal* for December, the results given by the electric tramways in regular work. It would be useful to add to this list the Marseille tramway and the three tramways at Paris worked with accumulators. Unfortunately the results of working are combined in the same group with other lines making use of other means of traction, horse-power, steam, &c.

	Montferrond to Royal.	Lyons to St. Foix lès Lyon.	Bordeaux-Bouseat to Vigeau.
Total length in use to June 30th, 1894, in kilometres	7	3	5
Cost of installation, in francs ...	2,700,000	206,221	576,924
Receipts of half-year, in francs ...	137,202	15,027	68,521
Expense of half-year, in francs ...	88.171	21,074	51,035
Net returns of half-year, francs ..	+ 49,031	− 5,147	+ 17,486
Linear returns per kilometre, in francs	19,600	5,309	13,704
Outlay per kilometre, in francs ...	12,500	7,025	10,707
Net return	+ 7,004	− 1,716	+ 3,497
Ratio of outlay to receipts ...	0·64	1·32	0 34
Daily receipts per kilom., francs	108	29	76

Electric traction on all these lines.

The table from which these figures are borrowed is most instructive. We see, for instance, to take extreme figures, that a certain tramway for passengers and goods takes daily receipts of 2 francs per kilometre, loses 500 francs per kilometre half yearly and gives 2·31 as the ratio of outlay to receipts. But the palm must certainly be awarded to the line from Sévres to Versailles, which, in spite of a daily receipt of 58 francs per kilometre, has lost 58,072 francs per kilometre, and gives 6·57 as the ratio of outlay to receipts.

The tramway which enjoys the highest receipts per kilometre is the cable line of Bolleville with 533 francs daily per kilometre, but the proportion of outlay to receipts is not as favourable, 0·84.

The line from the Market des Capucins to the cemetery Saint Pierre, at Marseille, gives the lowest proportion of expenses to returns, and consequently the best account of its working, 0·51. Its length is 3 kilometres, and its daily receipts are 269 francs per kilometre.

We see from the table that the two tramways of Bordeaux and Clermont-Ferrard give, in total, satisfactory results. As for that of Lyon (Saint Just) its conditions of working are so bad that we cannot draw any conclusions from the figures presented by the Department of Railways. We wait with impatient curiosity for the results of the tramways at Havre where, for the first time in France, animal haulage has been entirely replaced by electric traction.

SMOKE PREVENTION AND ELLIOTT'S PATENT.

Technology Quarterly contains a paper by H. J. Williams, in which the question of smoke is very well considered, attention being directed to the means that have been employed for prevention of smoke, as well as to the causes of its production. While the domestic fire is set down as in the aggregate responsible for a very large amount of the smoke of cities, we need hardly refer to this source, except to point out that gas, if cheap enough, would perform all the work required in a house, and that it appears to us that a small gas producer could be made almost like the ordinary brick lined stoves, but with down draught in place of up draught, that would most efficiently do the work required. Mr. Williams thinks that even ordinary illuminating gas could be, by suitable means, employed to heat houses nearly as cheaply as coal fires. But what of the domestic Abigail?

He passes over metallurgical operations, which "are compelled to use smoky fires" to prevent oxidation of products, and claims for boiler fires the major portion of all the smoke produced, for power plants have to contend with the ignorance of firemen, whose only care appears to be to keep up steam regardless of consequences.

This is all very well, and we would not claim for firemen a high standard of knowledge. At the same time it is often most difficult to keep up steam at times of exceptional difficulty and not make smoke. An extra quantity of dirt in the coal may compel a man to clean his fires half an hour earlier than usual, and throw him entirely off his routine as to his time, which he may as a rule try to arrange in such a way that the approach of the dinner hour allows him to run the water level down, to be made up by feeding up during the stoppage.

Such a lowering of the water level enables one fire at a time to be cleaned while the others are simply making steam, but are not heating the comparatively cold feed water. But if cleaning is made half an hour sooner all this is upset and feed must be turned on with the fires or some of them charged with green coal.

Bituminous coals carry from 20 to 35 per cent. of volatile matter which consists of water and light non-smoking hydrocarbons of the character of marsh gas, and of more complex heavy hydro-carbons which dissociate at a red heat as follows: $C_2 H_2 = CH_4 + C$. The products are marsh gas, which burns when supplied with oxygen, and flocculent carbon which burns with greater difficulty, and the author thinks that a temperature of 2,000° is necessary for this combustion, even if the air supply be heated and thoroughly mixed with the gas, otherwise the carbon is discharged as soot. In ordinary firing necessary conditions are rarely present. (1) The open doors at firing times let in air in enormously excessive volume. (2) The fresh fuel cools the fire. (3) The water vapour and gases driven off the fuel absorb heat which becomes latent. (4) The carbon dioxide formed by the air which touches the fuel on the grate surface absorbs heat as it passes through the fire and becomes reduced to the monoxide, and "*only a part of this absorbed heat is given out again during the combustion which follows.*" We cannot see how this italicised paragraph can be sustained. If heat is absorbed by reduction it must be again set free on re-oxidation of the reduced product. (5) The combustible gases carry so much nitrogen with them and carbon dioxide from the grate that they are, as it were, blanketed off from the oxygen, and if cooling takes place below the critical point there will be combustible gas and oxygen flowing together yet not combining. Combustion is thus a very complex operation. In all the above, except the sentence we have italicised, we agree with the author, as well as in his claim, for the necessity of fresh air above the fuel when the fire is thick. But we believe a thick fire is necessary. We would try to keep it so thick that no carbon dioxide could escape at its surface and then deal, above that surface, with all the gases. Abundant smoke may mean little loss. Tests have been made showing that the soot from very smoky fires only represents ·33 to ·5 per cent., or 7·5 to 11·2 lbs. of carbon per ton of coal. But did these tests take into account the escaping monoxide, and, possibly, other combustible gas?

Now a smoke-preventing device, to be efficient, must be able to maintain a high temperature so as to insure the combustion of the separated carbon; must be regular in its action under conditions which vary, such as charging fresh fuel, cleaning, inattention, and must not be liable to get out of order, nor be costly to operate. It must also have capacity up to forcing the boiler, and be applicable to various forms of boiler, durable and not costly or injurious to the boilers, &c.

Capacity is the point in which almost all devices fail. There are few of the better devices but what can do all they claim to do under *special* conditions. In St. Louis, furnaces burning 18 to 20 lbs. per foot of grate, are capable of being made to show good smoke records, but they are forced beyond this rate, and are made to burn (we should have said dispose of) 30 lbs. of fuel per square foot, a fault which prevails also in the Eastern States. Thus much smoke could be prevented simply by adequate boiler room. Smoke devices, unfortunately, reduce boiler capacity. This appears to be due to the fact that the better combustion of the hydrogens prevents so rapid a combustion upon the grate, and of 39 careful tests in Chicago, the average result was a capacity only 74 per cent. of the normal, the boiler work being reduced 28 per cent. and the fuel consumption per unit of work increased 2 per cent. It is obvious that all these devices must have been faulty, for more fuel could not have been burned and done less work per pound of fuel. Clearly the extra work performed must all have gone in heating a greater excess of air.

The St. Louis Smoke Commission classifies devices under seven heads: 1. Steam jets. 2. Fire-brick arches. 3. Hollow walls for air heating. 4. Coking arches or chambers. 5. Double combustion. 6. Down draught. 7. Stoking machines.

Steam jets are really draught assisters and are said to yield good results, except when firing is careless. They require adjustment to suit varying conditions. We might instance the Meldrum furnace as a good example of forced draught by means of well arranged steam jets, because the Meldrum system provides for the necessary air above the furnace which many systems of jet neglect entirely.

Fire-brick arches and cell work placed at or near the bridge are soon burned out, but with care can be made to give good results. Their action is regenerative. We fear they are often overdone and made to offer too great an obstruction to the draught, and in such a case the draught must be assisted or the capacity of the furnace will be reduced, but draught cannot be reduced without adding to the thickness of the fire or there will be an excess of air used.

Hollow walls for heating air are good enough in theory. The author says they fail by becoming clogged and by general want of capacity. We do not see how any heated draught can keep a furnace going as before, unless the draught is helped so as to put the same weight of air through the fire as the natural draught put through when the air was cold.

Coking arches are said to fail by fluxing with the coal ash at high temperatures, while double combustion furnaces fed alternately are said to allow a large excess of air to be passed through to the chimney with corresponding loss of heat.

Down draught furnaces are thought more promising in which the fuel is charged on top and the grate is built up of water tubes. Sometimes a second grate is put below to catch any fuel that may drop through the upper water grate.

The system is good as a smoke preventer, but the grate is the weak point with impure water, and we should doubt the life of such a system though it is obviously an adaptation of the "producer" and worth study.

Mechanical stokers have little capacity for being forced, says Mr. Williams, and this is a good deal the case. The fuel bed is in a given state and cannot be got up to twice its size in a few minutes. Then to increase the draught means burning off the back of the bars sooner than usual and admitting free air. When forced, a mechanical stoker requires to be assisted by hand firing to get up the fuel bed. At the best of times the back of the fire is abnormally thin as the fuel burns away and this tells against the system. Coking machines will, however, work smokelessly, but sprinklers make a light smoke continuously, but are inadmissible when flue dust cannot be allowed to come from the chimney top. The author has found that coking or clinkering coals could not be worked in mechanical stokers because they choked the bars and impeded its movement. We do

not think there has been so much trouble with English mechanical stokers in this respect, but Roney stokers, which were all right with Pittsburg coal, became irregular with Illinois coal containing 17 to 18 per cent. of ash. The Roney stoker has, however, an inclined step grate, and clinkers of 100 lbs. were not infrequent, one of which took three-quarters of an hour to extract. Mechanical stokers are essentially machines for steady loads. We are not surprised to learn that the flue gas analysis of one of the St. Louis electric light plants showed 75 per cent. excess of air from 6 mechanical stokers at normal loads, whereas 25 per cent. is a sufficient excess for thick fires.

This air excess is the trouble with the mechanical stoker generally, and can only be overcome so far as we can see by a short grate and a combustion pit, at the rear of the grate, of some depth, in which the fuel from the grate can be finished off, thus always having a depth of fuel in the grate, and so avoiding the free places for air admission, while providing for the finishing of the combustion in a suitable pit, which ought to be capable of clearing from below. This, of course, precludes the idea of boilers of internally fired type, unless modified in construction by the addition of a down take through the shell bottom, a construction fraught with difficulty and danger to the boiler shell.

The author has found the Standard smokeless furnace of St. Louis to be an excellent device. It is a sort of coking stoker, with a coking plate and a step grate, and it increases the furnace capacity from 10 to 20 per cent., and will develop full capacity, but should have half an hour's notice of any largely increased call for steam.

Our own opinion of smoke is very much that it results from simple lack of temperature, and is the direct result of a water cooled furnace, and we think it probable that in the furnace of a Lancashire boiler, for example, efficient smokeless combustion could be obtained by more or less lining of the furnace with best fire-brick. Smoke is already so nearly prevented, even in ordinary furnaces, that it appears likely that a little more care of the initial temperature might wholly prevent it. Thus, while a complete furnace of brick could hardly fail to give a perfect combustion. the same end might be obtained by a series of narrow rings lining the furnace, alternating with unlined gaps.

The number of rings could be decreased to the minimum found necessary. They would serve a double purpose, for in addition to conserving the temperature and aiding combustion, they would promote admixture and would also prevent the flow of gas along the cold furnace crown in a continuous stream. No gas particle could move forward without passing round the obstructing arches. We believe this system would prove effective both with hand firing and mechanical stoking, but in hand firing there should be some means of checking the draught during stoking, so as to moderate the enormous inrush of air at such times.

Referring to gas fuel, the author states that this would settle the smoke question once for all, but ordinary coal and water gas are out of the question because of their expense; but fuel gas has been made from Illinois coal for as low as fourpence per 1,000 cubic feet, and at first sight this seems to be within reach. This has been investigated in Pittsburg with the following results :—

48·17 pounds of coal will produce 1,000 cubic feet of gas. The gas has a calorific capacity of 243,391 units. This is equal to 5,053 units per pound of the coal from which it is made. Yet the coal actually yielded 11,173 units in a calorimetre test. Therefore the gas had an efficiency of 45·2 per cent. This is not very clear. Let us suppose that two-thirds of the coal was carbon ; then in 1,000 feet there should be the heat due to the further oxidation of the monoxide derived from 32 pounds of carbon. This is equal to 10,100 units per pound of carbon, or, say, 10,000, so that from the 32 lbs. we should expect 320,000 heat units per 1,000 feet of gas. The coal must have been very poor only to show 11,173 units. The coal, it is stated, should be capable, theoretically, of evaporating 11·56 lbs. of water, whence the gas, at 45·2 per cent., will only evaporate 5·23 lbs. In our estimate of 320,000 units, we have omitted entirely the heat of the first oxidation, and in boilers fed directly from gas producers before the gas has been cooled, this additional quantity of heat is available to the extent of over 40 per cent. The author gives no analysis of either the coal or the gas, so we cannot see where the discrepancy comes in, but we do not think that the presentation is made at all fairly. At the same time we doubt very much the efficacy of gas firing. There appears a difficulty in transferring the heat from the purple blue transparent flame of carbon monoxide to the boiler plates, but Mr. Williams surely cannot mean us to understand that gas does not give out in its production and final complete burning exactly as much heat as is given out by the coal from which the gas is produced. The end of both is the same, namely, carbon dioxide and water, or rather steam gas. *Heat cannot be annihilated.*—The coal at 50 per cent. efficiency will, says our author, evaporate 5·78 lbs. of water and the gas at 90 per cent. efficiency, only 4·71 pounds. At 6 cents a bushel for coal and 8 cents per 1,000 feet for gas, the fuel will come to 13 cents per 1,000 pounds evaporated with coal and 35·2 cents with gas. But surely there is a great error here. To evaporate the 1,000 pounds with coal requires 173 pounds of coal at a cost of 13 cents, and the gas to do the like duty is 4,400 cubic feet derived from 212·3 pounds of coal. Yet the gas cost is rated at 8 cents per 1,000 feet. Why is it not rated at $\frac{212{\cdot}3}{173}$ of 13 cents = 16 cents, not 35·2 cents. There must have been something radically wrong with the gas producing plant. It costs less to pitch coal into a gas producer than to fire it carefully upon the grate of a boiler, and having present Mr. Williams's figures we cannot but reject them as unreliable for ordinary use. It looks as though in his estimate he had simply taken the bare price of coal with no addition for wages and in the cost of gas had added in the wages ; and even had this error not been made, as it evidently has been made, we should not care to accept the figures. They are not sufficiently consistent. But gas firing as we have said has not been an unqualified success with ordinary steam boiler settings. There is no radiating power in the flames, and to be a success it would appear as though the gas should be introduced upward through a mass of perforated brickwork and mixed with the necessary air at the base of the brickwork so as to raise this to incandescence, and thus secure a radiating mass as well as steadiness in steam production. Mr. Thwaites informs us he has tried gas firing and found the same difficulty, and certainly gas is better suited for direct production of power by combustion in the power cylinder itself without the interposition of a steam boiler, and the production of steam which cannot perform work unless it be maintained at a given temperature.

As regards smoke annihilation of the type now being brought before the investing public in the shape of Elliott's patent, we look on such attempts with grave doubts, not the less grave because it is thought necessary to ask the public for so much money. Like the Livet refuse destructor and the earlier Hopcraft furnace, these full page advertisements throughout many papers in the land are suspicious. In the present case there is no information given of the process, though the claims made would appear to indicate that a forced draught is the means employed to enable the process to be worked, and a forced draught will account for five out of six of the advantages claimed to accrue from using the process, which is presumably a water washing process to throw down dust and soot from suspension and dissolve the acids and other soluble portions of the flue gases. The writer remembers reading an account of a smoke washing plant, over 20 years ago, so that there is nothing new in smoke washing. We do not doubt the possibility of cleansing smoke by suitably arranged water sprays, but we do question the possibility of at all universally applying the process, and strongly doubt the figures as to the "sources of profit open to the company." Why are we given no figures of the financial results in these long and wordy advertisements? There is nothing in smoke washing that any steam user cannot more cheaply do for himself, and obtain all the advantages that may accrue from the forced draught employed.

We have no objection to the principle of smoke washing itself, but we doubt the claims made for the Elliott machine that absolute removal of sulphur products is effected. When the Borough Analyst of Glasgow tested a smoke washing plant, he found it removed half the sulphur—a desirable reduction, certainly. We do hear, however, that the Elliott machine requires a large amount of power, and we have obtained a prospectus, which we were told was all the information to be got, and find that it gives absolutely no financial results, and not a word is said about the power

required to work the process." But we notice that the *Standard* is quoted as saying that the system will save 60 per cent. of the fuel. This statement, on the face of it, stamps the *Standard* as an ignorant and untrustworthy guide in things mechanical, and it puts one irresistibly in mind of the man, who being assured by the vendor of a patent stove that it would save half his fuel, wished to purchase two so as to save it all.

To ask £120,000 for the so-called patents is perfectly absurd. We do not see how a patent can be of the slightest value. Smoke washing cannot be patented. It has been effected too many years ago for that. In asking a large sum the promoters of the company do not give a single report from any reliable engineer as to the process generally, and appear to have been guided throughout by a belief that the investing public have forgotten the Hopcraft furnace, the Field engine, and other brilliant and revolutionary schemes.

We are glad to see Mr. D. K. Clark is said to have given an exhaustive report. Very good. The Hopcraft furnace was floated into fame by a report which purported to be Mr. D. K. Clark's.

We should caution investors to be very cautious of so overloaded a scheme, for a capital of £6,000 would have been ample to have worked the entire thing, and the inventor and vendor could have honestly claimed a large share in any profits made; as it is, this vendor-inventor is to rake in £45,000 in hard cash, and a further £30,000 in fully paid up shares, which will be speedily got rid of during the few days when the shares will be rigged to a premium. Why, poor little Hopcraft only got £25,000 for his patent, and it was a long time before anyone found out that it was an old scheme. We note, however, that the Elliott prospectus is very skilfully made up to appear to an ordinary reader as though only £30,000 in shares were being paid for the patents.

ON A MAGNETOMETER FOR SHOWING THE INFLUENCE OF TEMPERATURE ON THE MAGNETISATION OF IRON AND OTHER MAGNETIC SUBSTANCES.*

By HENRY WILDE, F.R.S.

It is not a little remarkable that, in this age of active experimental research, there should be any doubt as to the influence of temperature on the magnetic power of iron and other magnetic substances; yet from the 17th century to the present time, the most discordant opinions have prevailed on this subject. Barlow, in the year 1822, found that the magnetic power of bars of iron which he experimented upon, as measured by the deflections of a compass needle, *increased* with the temperature up to a dull red heat, at which it was the strongest; but at a bright red heat, all magnetic action of the iron suddenly disappeared.† Scoresby, Christie, and others, have also noted a similar increase in the magnetic power of iron with increase of temperature, when measured by the same means. Faraday, on the other hand, described experiments to show that the magnetic power of iron *diminished* with increase of temperature. He also found that iron at a bright red heat was not entirely insensible to the action of large magnetising forces.

More recently, Rowland‡ and Hopkinson,§ by the employment of electro-dynamic methods and the needle indications of Barlow, have also found an increase in the magnetic power of iron with increase of temperature.

These experimenters were, however, the first to recognise that the apparent increase of the magnetic power of iron, up to the dull red heat, only held good for small magnetising forces, and, further, they found with Faraday, that the power diminished for large magnetising forces with ascending temperatures. Rowland extended his observations to the magnetisation of nickel and cobalt, and found that the magnetic behavior of these metals with increase of temperature was the same as he had observed in iron.

Experiments have also recently been made by Rücker on the effects of temperature on the natural magnet (*magnetite*), and he has found that the magnetic power of this mineral apparently increases with ascending temperature. A later pronouncement on this subject was made by the President of the Royal Society (Sir G. G. Stokes) in the year 1890, in the course of his anniversary address, in which he stated that, it was generally believed that the susceptibility or magnetisation of iron decreased with the temperature, but, on the contrary, it had been recently found that the susceptibility was enormously increased with ascending temperatures.* This generalisation was afterwards limited, through my representations, to the action of small magnetising forces.†

In my paper on "The Unsymmetrical Distribution of Terrestrial Magnetism,"‡ it was shown that by heating small surfaces of the thin sheet iron covering the ocean areas of the mapped globe, strong polarity was induced at the junction of the heated parts, just as when the magnetic continuity of the iron was interrupted by cutting through the same parts, of the iron in an equatorial direction. Although this experiment appeared to me to demonstrate conclusively that the magnetic power of iron was reduced at comparatively low temperatures and with small magnetising forces, yet, from the contradictory results which had been obtained by other experimenters, directly opposite conclusions as to the magnetic intensities of the land and ocean areas respectively might, with some show of reason, be drawn from those which I had arrived at. The important bearing which the influence of temperature has upon the phenomena of terrestrial magnetism, induced me to undertake an investigation into the causes of the conflicting results hitherto obtained, with the hope, also, that I might be able to extend still further our knowledge of magnetic substances.

The results of my experiments, which are embodied in a paper read before the Royal Society,§ confirm the general law of the diminution of the magnetisation of magnetic substances with increase of temperature for *small* as well as for *large* magnetising forces. I have also demonstrated in this paper that the apparent increase of the magnetic power of heated iron, magnetite, and nickel is so small as to be a negligible quantity in general magnetic phenomena and terrestrial magnetism, and is due to a surface resistance of these substances which disappears: (1) On the application of heat; (2) by the action of strong magnetising forces; (3) by diminishing the mass of the magnetic substance acted upon by the magnetising force.

I have further shown that the surface resistance of cobalt at normal temperatures is so great, as to require a tractive force equal to 373 lbs. per square inch, acting on a minute quantity of the metal, to overcome it.

The general results of my experiments have been confirmed by M. P. Curie, in two able papers in the *Comptes Rendus* of the French Academy for April and May of the present year. M. Curie also agrees with my conclusion that the apparent increase of the magnetisation of iron, magnetite, and nickel is anomalous, and masks the principal phenomena of the decrease of magnetic power with ascending temperatures. M. Curie has extended his observations to the magnetic behaviour of gaseous oxygen, and has found with Prof. Dewar, when experimenting with this element in a liquid state, a decrease of power with increase of temperature.

The general law of the diminution of the magnetisation of all known magnetic substances with increasing temperatures is now completely established.

In connection with this brief summary of experiments on the influence of temperature on magnetic substances, I would direct attention to the close analogy, if not an actual relation, which subsists between the anomalous surface resistance of cold iron to magnetisation and its anomalous property of resisting chemical action. Schönbein and Faraday have shown that bright iron wire, slightly oxidised by heat, is quite insensible to the action of strong nitric acid.‖ Not only is there no reaction under these conditions, but the oxidised wire has the property of inducing voltaic passivity

* Read before the Manchester Literary and Philosophical Society. Received October 2nd, 1894.
† *Phil. Trans.*, 1822, p. 117.
‡ *Phil. Mag.*, 1874, Vol. lxviii., p. 321.
§ *Phil. Trans.*, A, 1889, Vol. clxxx., p. 443.

* *Nature*, December 11th, 1890.
† *Proc. Roy. Soc.*, December 1st, 1890.
‡ *Proc. Roy. Soc.*, January 22nd, 1891.
§ *Proc. Roy. Soc.*, June 11th, 1891.
‖ *Phil. Mag.*, 1836, Vol. ix., pp. 53—65.

in a number of pieces of bright iron wire by simple contact with them when immersed in the acid. Further, a passive bright wire has the property of inducing the passive condition in other pieces of ordinary bright iron wire.

It is admitted on all hands that this anomalous voltaic condition of iron is a surface resistance, as it disappears (1) by abrasion; (2) by the action of dilute nitric acid; and (3) by the application of heat to the wire.

To affirm, therefore, as a general property of iron, that its magnetic power increases with the temperature, is as irrational as to maintain that iron throughout its substance is, like gold and platinum, insensible to the action of strong nitric acid.

For demonstrating the influence of temperature on magnetic substances, I have devised a magnetometer which is shown in the accompanying figure (fig. 1).

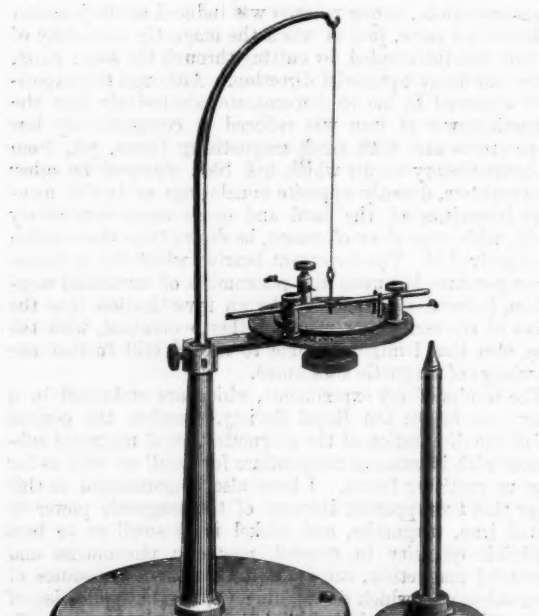


Fig. 1.

The instrument consists of a declination needle freely suspended from a double fibre of untwisted silk over a disc of brass. One end of the needle is thickly covered with spun silk to prevent the weakening of its magnetism by close proximity to the heated substance under examination. The excursions of the needle are limited in both directions by pins inserted a little distance apart on a diameter near the edge of the disc. The disc is pivoted on the end of an arm, to which it can be clamped firmly by means of a milled screw when the needle is drawn out of the magnetic meridian. Three binding screws are mounted at equal distances from each other round the circumference of a circular table, which has an independent movement round the disc. The magnetic substances are held in loops of platinum wire fixed by the binding screws to the table, and the properties of the specimens can be examined in succession.

The action of the instrument is as follows:—The needle is drawn out of the magnetic meridian from 15° to 20° by turning the disc on its axis. The magnetic substance is then brought round towards the needle until equilibrium is established between its magnetism and the horizontal component of the earth's magnetism. The magnetic substance is heated by a small gas flame from below; when the needle recedes from heated iron, magnetite, and nickel, and advances again when the source of heat is removed; thereby indicating a decrease of magnetic power for these substance. On the other hand, the needle advances towards cobalt when heated, and recedes when the metal is cooled, by reason of its enormous surface resistance, which only disappears, as I have said, under the action of powerful magnetising forces.

ON THE PRICE OF THE OZONE.

By Dr. O. FRÖLICH.

In the issue of December 7th the Electrical Review does me the honour to reprint my article "On the practical applications of ozone," but adds some remarks of its own which would have quite a crushing effect if they were true. In those lines it is asserted that the quantity of ozone (O^3), viz., 20 gr., produced, per horse-power hour, as mentioned in my article on Siemens & Halske's apparatus, is of insignificant smallness, does not allow of any considerable application, and that other apparatus produce much more of ozone.

In the following I beg to defend "our" ozone. First, I mention the technical efficiency of the said quantity of 20 gr. of ozone, the amount of electrical energy necessary for its production not costing more at Berlin than 2d. 50 kilos of linen are bleached by this quantity of ozone, as well as by bleaching on the grass in fine weather during three days. 40 kilos of potato starch, are by the same quantity and in presence of some chlorine, bleached and refined in such a degree that the colour becomes a beautiful white, and that all the bad smell and taste is removed.

If this refined potato starch is roasted, and the ozonisation continued, we obtain, at a small additional cost, a product which resembles in every respect gum Arabic, and has more than double the value of starch gum; 20 gr. of ozone are sufficient for the production of 30 kilos of this product.

If the same small quantity of ozone is put into an ordinary room, the smell and the effect on human lungs are so intense that healthy persons are very rarely able to remain in the room; the same quantity of ozone is sufficient to ozonise a great room of 8,000 cubic metres in such a way that healthy persons can just endure it.

If the effect of the same quantity of ozone is compared to that of peroxide of hydrogen, a product which has also a good bleaching effect, and, like ozone, does not form obnoxious or disagreeable products, we find that this quantity of ozone has the same oxidising effect as ½ kilo. of the ordinary solution of peroxide of hydrogen; but the said quantity of ozone can be made at Berlin at half the cost of the solution, and where coals are cheap, still cheaper.

These examples show that the price of the ozone produced by the apparatus of Siemens & Halske is, for several technical applications, not at all too high; also the plant of bleaching by ozone, which is carried on at Greiffenberg since one and a-half years, would not be economical, and the other plants, now in preparation, could not have been thought of.

I cannot but doubt that apparatus mentioned in this journal give much more ozone than those of Siemens & Halske, because the energy necessary for the production of ozone by the silent electrical discharge cannot be below a certain minimum; but not being acquainted with the construction of those apparatus, I will refrain from animadverting on this point.

Perhaps the difference in the figures of ozone production by the English and by our apparatus, may be attributed to the different ways of titration. We measure the ozone produced by each 1 horse-power apparatus by its absorption in a solution of iodine of potassium, and by determining the precipitated quantity of iodine in the ordinary manner. A great many of these titrations have been made, and they have completely agreed with those taken by the Imperial Sanitary Board of Berlin by the same apparatus.

The mentioned additional remarks in this journal seem to show that in London ozone apparatus are in use for treatment of tuberculosis with good success. It is true that the Imperial Sanitary Board has proved that bacilli in the air and upon the walls cannot with certainty be destroyed by ozone; but perhaps the effect of the ozone in this case is chemical, and therefore not at all improbable.

As we remarked above, the energy required for ozonising a great establishment for medical purpose amounts only to some tenths of 1 horse-power, and, therefore, conclusions in respect of the industrial application of ozone, in general, cannot well be derived from a plan of that kind.

ALUMINIUM v. STEEL.

So far as mere strength is a desirable factor, there is nothing to be said in favour of aluminium as a material of construction in place of steel. The extreme lightness of aluminium has given rise to very erroneous ideas as to its utility in bridge building and for similar purposes. Prof. Thurston, discussing the question of the materials of aeronautic engineering in *Cassier's Magazine*, says steel is three times as heavy as aluminium, and four to five times its strength, and is, therefore, the better material to employ where strength is in question. He takes a common sense view of the art of flying. A locomotive weighs, he tells us, about 100 to 150 lbs. per horse-power, a marine engine from 200 to 600 lbs., the machinery of torpedo boats as little as 100 lbs., while a horse weighs 1,500 or 2,000 lbs., and a man can work at the rate of 1 horse-power for 750 lbs. of weight at his best, and muscular fibre is stressed to about 100 lbs. per inch of sectional area as a maximum. Mullenhoff reports the stress per unit section of a bird's muscles at 15 to 20 lbs. per inch, while Penard states that a feather has a tenacity of 45,500 lbs. per square inch, being nearly equal to soft iron, but the density is but a third of iron, so that it is six-fold better for aeronautic purposes than iron. Now a bird, as a whole, is said to certainly not weigh more than 20 or 25 lbs. per horse-power, and as a maximum for aeronautical machinery we may take 25 lbs. About half this weight should, however, be striven for, and the professor looks on it as a wonderful thing that a bird with low stresses and bulky fuel should be able to carry into the air extraneous loads 50 per cent. of their own weight, and, unloaded, travel a thousand miles a day without a stop. How, he asks, are we to seek the same results? There are three courses obvious :—1. Reduction of weight of material by improved design and proportion. 2. Increase in the ratio of the strength of a material to its density. 3. Increased velocity of motion of the power machinery. What has, so far, been effected? The prize engine of the British Aeronautical Society weighed 16 lbs. per horse-power, Maxim's engine and boiler weighed 10 lbs., Langley's engine alone only 6 lbs. per horse-power.

In a list of materials, steel stands first with a length of 22,922 feet for a bar self-supporting. Aluminium is next with 22,285, and wrought-iron third with 15,000. Higher class steel may even reach 100,000 feet self suspended, and nothing in Nature, organic or otherwise, is known that can compete with steel, except so far as they may have a special value as coverings for aeroplanes.

Copper added to aluminium increases the density slowly and the tenacity rapidly, so that an alloy containing only 6 per cent. of copper will sustain a pendant length of 40,000 feet, and such an alloy may be better than steel at 120,000 lbs. tenacity.

Magnesium, with a specific gravity of only 1·74, would appear at first sight suited for aeronautic construction; but it has a low tenacity, only 22,000 to 32,000 lbs. per inch, and Prof. Thurston has so far found no alloy of magnesium of any value for the purpose. All things considered, then, steel, in fine ribbons, wires, or thin tubes, with a tenacity of 300,000 lbs., is the leading material for a flyer, and even in thin sheets, steel seems to rival paper or any other substance for the hulls, if such can be afforded.

Though Maxim claims that he has actually risen in the air upon his flyer, the immediate prospect of a true air ship is decidedly vague. Mr. Maxim wisely set a low limit to his flight, and seems decidedly "broke up" by the very few inches of coming down. So far as mere flight is under consideration, we do not see very serious objections to the possibility of getting into the air and keeping there while the fuel store lasts, or water can be maintained in the boiler. Several miles even may be covered, but even a flight must have an ending, and it is just this that presents the highest difficulty. How is a machine to be brought to a stop anywhere but upon some specially selected site?

As stated by Thurston, the problem is now no longer one of weight or power altogether, for Nature has been already surpassed on this score. Necessarily a flying machine must have size if it is to carry even a one-man crew, or it will be overloaded, and the difficulty of steering and balancing a huge aeroplane, or set of aeroplanes, will not be soon overcome. But granting all this, we are still face to face with the problem of coming to a stop in proper form. Nothing at present is more likely than that this will involve a new machine and, perhaps, a new crew. Mr. Duryea's article on practical flight in the same number deals with flight from a different point of view, and is interesting as a record of present knowledge of the subject.

THE METHODS OF RESUSCITATING VICTIMS OF ELECTRICAL ACCIDENTS.

The Académie de Médecine has been asked by the Minister of Public Works to draw up a code of instructions relating to the course to be pursued with victims of such accidents as are liable to occur in works where electricity is produced and along the course of electrical conductors. The following is the text of the instructions which the committee, composed of Messrs. Bouchard, D'Arsonval, Laborde and Gariel, has submitted for approval: When a person is the victim of an accident caused by contact with electrical conductors or generating machines, the contact may still exist when help arrives, or it may have ceased.

In the first case, special precautions must be taken to break off the contact, so as to prevent those coming to the rescue from becoming victims in their turn.

If possible, the generating machine should be immediately stopped. If this is not possible, the current should be interrupted by cutting the conductor with instruments in which the cutting part is separated from the handle by pieces of insulating material, or, better still, connection to earth or a shunt should be established by means of a conductor of low resistance, which will lessen the intensity of the current in that part where the victim is in contact with the main conductor.

These remarks are submitted as indications only; they will have to be elaborated by the special technical committee appointed by the Minister of Public Works.

As regards the instructions relating to first aid in cases of persons that have received a shock, or that are victims of some electrical accident, the committee proposes the following measures :—

The victim should first be conveyed to an airy apartment, three or four helpers being retained, and all other persons being sent away.

The garments should then be loosened, and every effort made to restore respiration and circulation. To restore respiration, recourse may he had principally to the two following methods: the rhythmic drawing forwards of the tongue, and artificial respiration.

1. *The Rhythmic Traction of the Tongue.*—Open the victim's mouth, and if the teeth are clenched, separate them by forcing them open with the fingers or any resisting body whatever, a piece of wood, a knife handle, the handle of a spoon or fork, the end of a cane, &c.

Take the fore part of the tongue firmly between the thumb and finger of the right hand, which may either be bare or covered with a piece of linen, a pocket handkerchief, for instance (to prevent slipping), and give it a series of strong pulls followed by relaxation in rhythmical succession, in imitation of the rhythmical movements of respiration itself, to the number of at least 20 per minute.

This operation should be performed without delay, and continued persistently for half an hour, an hour, or more.

2. *Artificial Respiration.*—Lay the victim on his back, with the shoulders slightly raised, the mouth open, and the tongue perfectly free.

Seize the arms by the elbows, bring them sharply down to the sides, then raise them above the head, describing an arc

of a circle; then bring them back to the original position against the sides.

Repeat these movements about 20 times a minute, continuing them until the natural respiration is restored.

It is best to begin always with the traction of the tongue, applying at the same time, if possible, the method of artificial respiration.

Moreover, while this is being done, efforts should be made to restore the circulation by rubbing the surface of the body, slapping it with the hands or with wet cloths, throwing cold water in the face from time to time, and holding ammonia or vinegar to the nose.—*L'Electricien.*

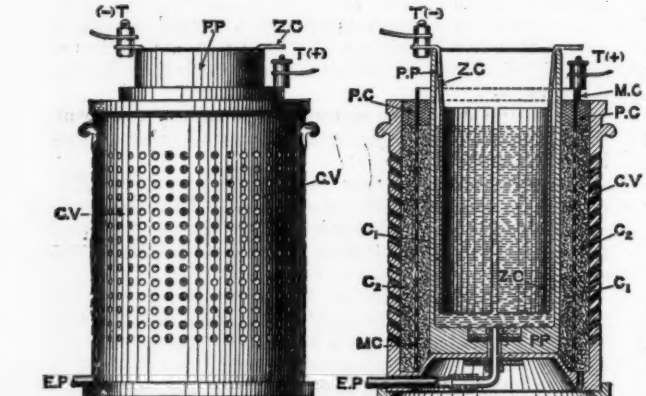
THE WALKER-WILKINS VOLTAIC BATTERY.

IT is claimed for this battery that the novelty of the cell is that it depends upon the atmosphere as its depolarising agent. By the action of the battery, nascent hydrogen occurs on the surface of the carbon constituting the negative element, and meeting with the condensed air in the pores of the carbon, combines with the oxygen of the same, the supply of air passing through the perforations. The hydrogen thus never assumes a gaseous form, and polarisation is prevented. The life of the electrolyte is said to be remarkable, and if a given quantity of current only be taken off per day, cells will work for almost an indefinite period. Sufficient height of porous cell is allowed for feeding purposes, and they require feeding once per week. The oxide is recovered from this exhausted solution with the greatest ease, and the solution can be resuscitated and used again from time to time with a percentage of loss in treatment.

Prof. Andrew Jamieson has made a report to the Patent Non-Polarising Voltaic Battery Company, of Birmingham, upon this battery, from which we extract the following particulars :—

Having received from you specimens of your non-polarising cells, with a request to test and report upon the same, I have much pleasure in stating that I consider them symmetrical in form, substantial in every detail, and thoroughly well made. Besides which, they have proved very efficient (chemical) generators of electrical energy.

As will be seen from the following drawing and index to parts, your cell is composed of an amalgamated split cylinder of zinc immersed in a solution of caustic potash, contained in a porous pot, placed concentrically within a larger perforated outer vessel. The



OUTSIDE VIEW. VERTICAL SECTION.

INDEX TO PARTS.

T (—)	represents	Negative terminal.	T (+)	represents	Positive terminal.
Z.C.	,,	Zinc cylinder.	C.V.	,,	Containing vessel.
P.P.	,,	Porous pot.	E.P.	,,	Emptying pipe.
P.C.	,,	Pitch covering.	D.P.	,,	Drain pipe.
C_1	,,	Carbon (powdered).	I.C.	,,	India-rubber corks.
C_2	,,	Carbon (granular).	E.S.	,,	Earthenware stand.
M.C.	,,	Metal cylinder.			

space between these vessels is packed with carbon; the carbon in contact with the porous pot being powdered, while that next the outer vessel is granular. The current is collected by means of a perforated nickel cylinder embedded in the granular carbon.

The advantages which you claim for this cell are:—1. Freedom from offensive or obnoxious fumes when working. 2. The simplicity of the cells and of the charging solution. 3. The almost entire absence of local action, and unnecessary waste of zinc.

I am glad to be able to corroborate these three claims. You also say that the cells have been introduced to meet the long felt want of a reliable primary cell which does not polarise, and which keeps a constant current up to a certain rate of output.

The following tests and curves will enable anyone who understands this important subject to judge how far your aims have been accomplished.

TESTS.

TABLE I.—WEIGHTS AND DIMENSIONS.

Two pint size.	Weight charged.	Dimensions.
No. 1...	19 lbs. 3 oz.	Total height,
No. 2...	19 ,, 5 ,,	including stand,
No. 3...	19 ,, 1 ,,	14″ × 8¼″ diameter.

THE TESTS TAKEN WERE AS FOLLOWS:

1. *Potential Current :—i.e.*, the variation of the potential difference at the terminals of each cell, due to the variation of the current strength in its external circuit.

2. *Total Output in Ampère-hours :—i.e.*, the cell was allowed to discharge through a resistance, so varied, as to keep the current constant.

3. *Recuperativity :—i.e.*, the rise of E.M.F., after being short-circuited through a copper voltameter for two days. The output in ampère-hours being measured by the weight of copper deposited in the voltameter.

4. *Internal Resistance*, as calculated from the results of Test 1, given in Tables II. and III.

Two galvanometers were used, one of very high resistance as a voltmeter, and the other of very low resistance as an ammeter. The high resistance galvanometer was so controlled as to give a deflection of 1 scale division for 0·0044 volt. A "Latimer Clark's Standard Cell" (of 1·454 volts at 15° C.) produced a deflection of 330 scale divisions; consequently, one scale division $= \frac{1{\cdot}454}{330} = {\cdot}0044$ volt.

The low resistance galvanometer was under strong magnetic control, and shunted by a short thick copper wire. It was then carefully calibrated to read in milliampères.

The following table shows the results of Test No. 1, or that of:—

THE POTENTIAL CURRENT TEST.

The cell was joined up, and its E.M.F. measured. A current of a certain value was then obtained from it for each period of five minutes. At the end of each such period the potential difference and current were simultaneously noted.

The external variable resistances were then reduced, so that the current was increased until it had risen from 0·156 ampère at the beginning to 1·346 at the end of the tests.

Eleven readings were thus obtained from cell No. 1.

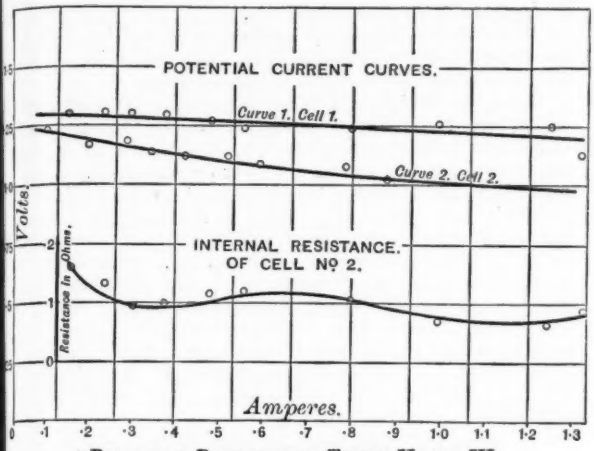
TABLE II.—POTENTIAL CURRENT TESTS.
(*For Cell No.* 1.)

Current in ampère.	P.D. in volts.	E.M.F. at end of each five minutes.
·000	...	1·457
·156	1·317	1·343
·228	1·305	1·334
·294	1·302	1·328
·371	1·290	1·324
·425	1·283	1·324
·467	1·272	1·324
·545	1·244	1·317
·778	1·231	1·311
1·000	1·216	1·290
1·241	1·199	1·285
1·346	1·049	1·264

The same test was again made with another cell, viz., No. 2.

TABLE III.—POTENTIAL CURRENT TESTS.
(*For Cell No.* 2.)

Current in ampère.	P.D. in volts.	E.M.F. at end of each five minutes.
·000	...	1·371
·100	1·229	1·244
·205	1·180	1·227
·290	1·152	1·207
·348	1·137	1·196
·422	1·123	1·185
·520	1·105	1·182
·590	1·087	1·176
·783	1·052	1·170
·870	1·023	1·164



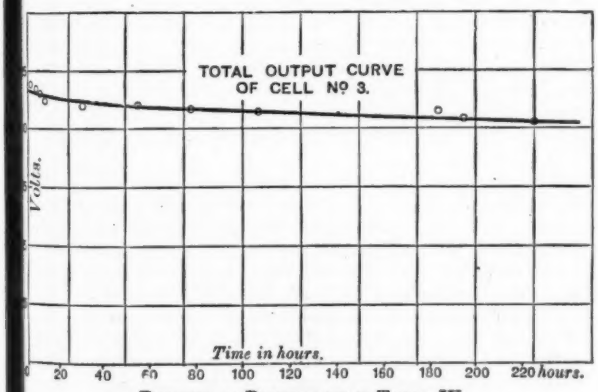
Results as Plotted from Tables II. and III.

Test II.—Total Output.

Table IV.—Output in Ampere-Hours.

(*For Cell No.* 3).

Time.	Current in ampères.	P.D. in volts.
0 hours.	1·1	1·173
·16 „	1·1	1·171
·33 „	1·1	1·169
·50 „	1·1	1·168
3·00 „	1·1	1·152
7·5 „	1·1	1·145
12 „	1·1	1·124
31·1 „	1·1	1·115
55· „	1·1	1·102
78·75 „	1·1	1·085
112· „	1·1	1·079
184· „	1·1	1·059
188·5 „	1·1	1·029
226·5 „	1·1	1·015



Results as Plotted from Table IV.

(*For Cell No.* 3.)

The gain in the voltameter plate was 292·628 grammes, which gives an output of 250 ampère-hours.

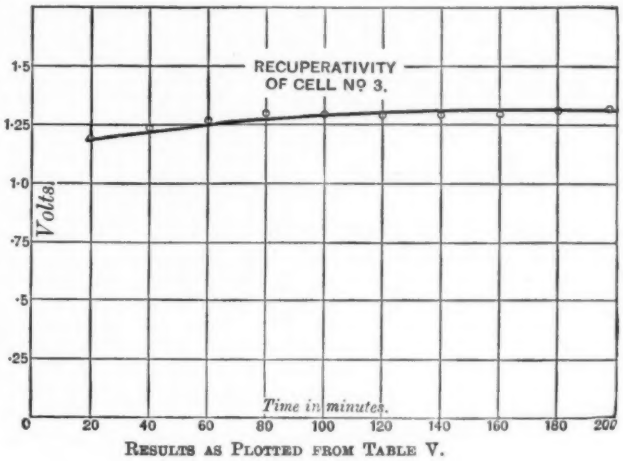
Weight of zinc used	·69 lb.
Theoretical weight of zinc required for the above output was only	·67 lb.

This gives the very high efficiency of 97 per cent. This result is better than that of any primary cell I have yet tested.

Test III.—Table V.—Recuperativity.

(*For Cell No.* 3.)

Time in minutes	E.M.F. in volts.
20	1·191
40	1·236
60	1·260
80	1·281
100	1·283
120	1·285
140	1·289
160	1·293
180	1·318
200	1·328



Results as Plotted from Table V.

Test IV.—Internal Resistance.

The potential difference at the end of each period of five minutes was deducted from the total E.M.F. at the end of each period. This gave the fall of voltage or pressure, inside the cell. Then, this internal voltage or *fall of potential inside the cell, divided by the current at the time, gave the apparent internal resistance of the cell.*

$$\text{By Ohm's law, } C = \frac{E}{R}$$

$$\therefore r = \frac{E - (P.D.)}{C},$$

Where r represents the internal resistance of the cell. From this formula (as calculated from Tables II. and III.) the *mean* internal resistances of the two battery cells were 0·112 and 0·161 ohms respectively.

Test V.

Having also received from you a specimen of your combined three cell oval type, with a request to test the same, I have much pleasure in stating that in all respects it has proved as satisfactory as the previous ones.

This battery consists of a combination of three cells, joined in parallel. Each cell, however, is similar in internal construction to those already described; but the carbon of each cell is surrounded by a thin perforated metal cylinder instead of the earthenware containing vessel, while another oval perforated vessel of the same material surrounds the three cells. This greatly reduces the weight for a given output. The total length, including the insulated handles, is 21 inches by 5¼ inches broad, and 11 inches high, the weight being approximately 30 lbs. Each set of three cells is intended to give a current of 6 ampères at about 1 volt potential difference.

My first test gave an output of 324 ampère-hours with a very small diminution of voltage, but after this output the cell was allowed to run down by mistake, between a Friday night and Monday morning, and thus the exact total output could not be ascertained.

The same cell was, however, then cleaned out and freshly charged with your caustic solution, whilst the zincs were carefully re-amalgamated.

A copper voltameter was placed in circuit, and the cell again started. A Weston standard voltmeter and milliampère meter were placed in circuit, and readings of the current, and potential difference were simultaneously noted throughout the trial.* The results were as follows:—

Table VI.—Total Output.

(*For the* 3 *Cell.*)

Time in hours.	Current in ampère.	P.D. in volts.
0 hours.	6·1	1·145
1 „	6·1	1·140
18 „	6·0	1·134
19 „	6·0	1·134
22 „	6·0	1·134
24 „	6·0	1·130
42 „	6·0	1·122
44 „	6·0	1·122
48 „	6·0	1·110
72 „	6·0	1·090
76 „	6·0	1·072
77 „	6·0	1·042
95 „	6·0	1·022
97 „	6·0	1·022
102 „	6·0	1·020
104 „	6·0	1·020
125 „	6·0	1·010
128 „	6·0	1·000

* The Weston meters had been most carefully compared with Lord Kelvin's latest standard balances and found to be correct.

The above table shows that the cell kept a remarkably constant current with a slight fall in voltage.

I have, therefore, much pleasure in affirming that your non-polarising cell is the best of its kind that I have ever tested.

I believe that it will prove very serviceable for driving electric motors for electric lighting, and for the electro-deposition of metals, where engines and dynamos are not available.

The statement that the cell is the "best of the kind I have ever tested" is misleading; the professor may have experimented with few or many, and those, possibly, bad examples. The E.M.F. is low, and the battery is *not* non-polarising. It dropped from 1·457 to 1·343 straight off, or 8 per cent. It is true this is not a great fall, but it is not insignificant. The cell is certainly simple, the solution cheap, and the results, as regards current and fall of E.M.F. *for the size of cell*, appear to be good, but caustic potash has, of course, been used repeatedly for primary batteries. The local action is very little, and the absence of fumes is a point in its favour; still, we cannot think Prof. Jamieson can be speaking seriously in stating that it will prove very serviceable for electric lighting. It will doubtless do for a small output, but the slow depolarising action of the air would not support current sufficient for heavy work. On the matter of primary batteries, we shall probably have something more to say ere long.

THE ARC LAMP.

Prof. Silvanus Thompson commenced, on Monday night, at the Society of Arts, a series of three Cantor lectures on the "Arc Lamp."

At the outset, the lecturer announced the form and order of his three lectures. In the first, he proposed to deal with the physics of the arc; in the second, he should dwell on the optics of the arc; and in the third lecture he should deal with the modern developments in the mechanism of the arc lamp.

First of all the lecturer corrected the generally understood date of the discovery of the arc. He ventured to put it earlier than the year 1809. The audience not objecting, Prof. Thompson went on to say that shortly after Volta made his pile publicly known, workers immediately commenced experimenting with it. Amongst others Sir Humphry Davy, at that time plain Humphry, worked with it, and in September of 1800 he recounted how he was able to produce sparks visible in daylight from the discharge of his primitive pile, and he found, on making sparks between different materials, that they were of different degrees of brightness, and amongst other materials, he mentioned that the bright spark visible in daylight was obtained by using well burnt charcoal. Davy had found that to render charcoal well conducting it must be hard, that is, well burnt.

Within a year of the foregoing, several other accounts appear in the *Philosophical Magazine;* and then Davy, in 1802, having become lecturer at the Royal Institution, describes, in the very first volume of the *Proceedings*, how he had obtained sparks, using again well burnt charcoal, and he continued to show these in his lectures on "Electricity." Tyndall records that in 1801, or 1802, Davy showed the carbon light, with batteries of 150 pairs of plates, in the theatre of the Royal Institution. The *Journal de Paris* for March 12th, 1802, announced how one Robertson, a well-known conjurer, would at the close of a conjuring entertainment exhibit the light of a galvanic pile brighter than the sun at noon-day, obtained between two shining carbons. Other persons are recorded to have shown the carbon light, and, at any rate, it became perfectly well known that a light could be obtained in such a way.

In the professor's opinion, there was no accurate distinction made in those early days between the mere spark obtained, and the continuous flame obtained by putting the points together and then separating them. From 1808 there was no question of this, however, for about this time Davy spoke of great things he hoped to accomplish, and asked for means to purchase a much larger battery. A battery of 2,000 cells was subscribed for, and with this Davy produced a phenomenon which attracted much attention, viz., the permanent production of a great flame. Going on to speak of the improvement in carbons, the lecturer said that in 1820 it was known that the carbon obtained from the inside of gas retorts was the hardest that could be obtained.

It was not until 1846 that the mechanical construction of an arc lamp received much attention. Staite then proposed to use two carbons parallel to one another, exactly in the same fashion as Jablochkoff did 20 or 30 years later. Others worked on the subject, including Grove, who also tried other materials than carbon. He found in the course of his experiments that the addition of volatile matter increased the length to which the arc could be drawn out. After dwelling upon the fact that the rekindling of the arc by means of a spark from a jar was claimed by many, the lecturer repeated one of Davy's experiments of striking an arc under a liquid, such as paraffin, which showed that to get a steady arc under such conditions was practically impossible. Arcs between carbon and metals were then shown. The arc produced between copper and carbon was a very uncertain and glimmering one; the colour also varied according to whether the carbon was positive or negative; the arc produced between carbon and zinc was a hissing one; the zinc was, however, shown under more favourable conditions. Taking an ordinary stick of battery zinc, the lecturer established the fact that when the zinc was positive, and the carbon negative, there was less noise. The arc between carbon and quicksilver was yellower and brighter, but it was a little more ghastly than a Welsbach, which is saying a great deal.

Prof. Thompson then proceeded to discuss the difference between the discharge from an induction coil and the arc discharge. The discharge was, to some extent, similar; but in the discharge between two brass knobs of an influence machine the light came mainly from gaseous volatile particles, and not from the solid matter forming the electrodes, whereas in the true arc the main light came from the solid matter of the electrodes, and a great deal depended on what that solid matter was. After describing the operation of striking the arc, the lecturer said that electricians had soon to discuss for arc lamps the relation between E.M.F. and current, quality of carbons, the size and length of the arc. They came across very strange facts; they found that the length of the arc did not quite go with the resistance, that is, to double the length of the arc would not double the resistance. The professor then gave the results of Cross and Shepherd's investigations into hissing and silent arcs, showing that though hissing arcs wanted a good deal less E.M.F. than a silent arc, yet a hissing arc could not be produced with a less E.M.F. than 15, a silent one requiring an E.M.F. of 39.

Then we heard the lecturer to advantage on the subject of the back E.M.F. of the arc, a favourite topic of the professor's, and one handled with the greatest skill; then we passed on to the transport of matter from one arc to another; in the hissing arc there was a large transport of matter, but in a silent one the matter transported was small. The recent experiments of Blondel were quoted as showing that there was only one direction in which matter was transported, *i.e.*, from the positive to the negative carbon. The lecturer then referred to another property of the arc, and one not universally known, the smell of the arc, a flaming arc, say one produced from a 2,000-volt alternating circuit, gave off a very perceptible odour. The peculiar blowpipe effect of magnetism on an arc lamp was next shown, and then Duncan experiments on the relation of pressure and arcs were dealt with.

Prof. Thompson, in concluding, said he had listened with the utmost delight to a paper of Prof. Ayrton's, read at Chicago, which cleared up a lot of matters concerning the arc; but unfortunately these original results had been destroyed by the fire which took place there. He had reason to hope, however, that Prof. Ayrton would once more take up the subject.

Will of the late Philip Rawson.—From the *Illustrated London News* we learn that the will of Mr. Philip Rawson, J.P., of Woodhurst, Crawley, Sussex, who died on November 12th, was proved on December 31st, the value of the personal estate amounting to £137,000.

TUNBRIDGE WELLS HILARIOUS.

[BY OUR SPECIAL COMMISSIONER.]

"It was a fortunate day for Tunbridge Wells when the Town Council elected Sir David Salomons as Mayor." So states the local *Argus*, and your Commissioner's is in perfect agreement with the Tunbridge Wells scribe.

On Saturday evening last, in returning the compliment which the inhabitants paid him on the day of his appointment, the Mayor invited a number of distinguished men from London (including your Commissioner, the Lord Mayor and Sheriffs, a few professors, &c.), and from other parts of the country to join them at a banquet in the Great Hall.

Your representative reached Cannon Street just in time to scramble into the South Eastern "express" whose engine was snorting like an arab steed longing to scour the plains, or rather, eager to show that the ill-natured comparison of a South Eastern flyer to a funeral procession had no real foundation; but alas! the train carried weight, and the hour in which we were allowed to cover the distance was exceeded by the proverbial ten minutes which constitutes absolute punctuality on this line. Fortunately, however, Profs. Ayrton and Hughes, Mr. F. H. Webb, and Captain Stiffe, late E.I.N., kept up an animated conversation with your Commissioner, so the "pace that kills" did not seriously incommode us.

On reaching our destination, and after stretching our stiff and weary limbs, we emerged from the subway, and were greeted with hearty cheers from a considerable crowd, the Ceylon Band at the same time playing the "Coronation" march, from "Le Prophéte." At the entrance to the Hall, on the opposite side of the road, a guard of honour was formed by a detachment of police under Chief Constable Prior, and of firemen under Captain Westbrook. Just here quite a ludicrous incident took place. The populace of Tunbridge Well had probably preconceived notions that the Lord Mayor was a big man, so when your six foot two-and-a-half inches commissioner crossed the road with Prof. Ayrton on one side of him, and Prof. Hughes on the other, the cheering which greeted them made it at once apparent that the trio had been mistaken for Sir Joseph Renals, and Aldermen Faudel Phillips and Samuels. Before the error was discovered we were in the reception room, or it might have led to serious consequences. Then after the real Lord Mayor had made his appearance, Sir David and his principal guests, announced by a fanfare of trumpets, entered the Great Hall shortly after half-past six o'clock, and walked in procession to the platform, which had been reserved for their use.

After the banquet and the usual loyal toasts, which were proposed in felicitous terms by Sir David, speeches, supposed to be limited to five minutes each, were fired off by various big guns. There was nothing electrical throughout the proceedings, excepting the fanfare of trumpets, whose frequency and variable periodicity gave your Commissioner a shock from which he has not yet recovered. That two fiends in human shape, and in gorgeous attire, could have produced such blasts as to knock down and shatter a pile of plates and dishes is almost beyond belief, but such was the case, and a musical friend explained the phenomenon by asserting that the pitch, the wave length, and amplitude of vibration of one of the upper partial tones produced by the trumpet corresponded exactly to the fundamental note given out by crockery when struck. Even the charming music discoursed by the band of the Royal Engineers failed to "soothe the savage breast;" indeed, it was rumoured that Sir David himself intends to abandon science for music, and that he contemplates writing an article on "The Trumpet as an Instrument of Torture, from the time of Tubal-Cain to the present day, with special reference to Municipal Gatherings."

Joking apart, however, the inhabitants of Tunbridge Wells may be heartily congratulated on having this year a mayor such as but few towns can boast. A University man; a scientific man who delights to surround himself with the leaders of light and learning of every kind; a man of great wealth and position; a lover of the beautiful country in which he resides; a friend to rich and poor alike, Sir David combines in himself every desirable attainment, and if nothing so sumptuous as the mayoral festivity of Saturday last has ever been witnessed in that delightful paradise for busy men and delicate persons, we make bold to add that no more memorable event in the history of Tunbridge Wells will be found than Sir David's tenure of office. Nothing can exceed his thoughtfulness, care, and sincere desire for the comfort and welfare of everybody with whom he has relations, and, finally, quoting the *Argus*, we again express our entire belief that Sir David's popular term of mayoralty will do untold good to the Kentish inland watering place, which, in addition to its natural attractions, will, next summer, be provided with electric lighting, due, we understand, to Sir David's enterprise.

COST OF WORKING AT THE PORTSMOUTH CENTRAL STATION.

It will be remembered that we published a fortnight ago some interesting figures concerning the working of the Portsmouth Corporation Electricity Works. We quoted them from a statement by Mr. Alderman Ellis, the chairman of the Lighting Committee, which was to the effect that the revenue for six months had been £3,228 11s. 9d., while the expenditure on coal, labour, and salaries was £1,773; the gross profit, subtracting expenses from income, being £1,455. It struck us that such figures for a first half year's working were phenomenal, and we determined to investigate them, as far as we could, on the spot. A representative of the Review, therefore, journeyed down to Portsmouth a few days ago, and had the complete figures set before him. The results are, perhaps, more striking from a closer inspection than they appeared from a cursory examination.

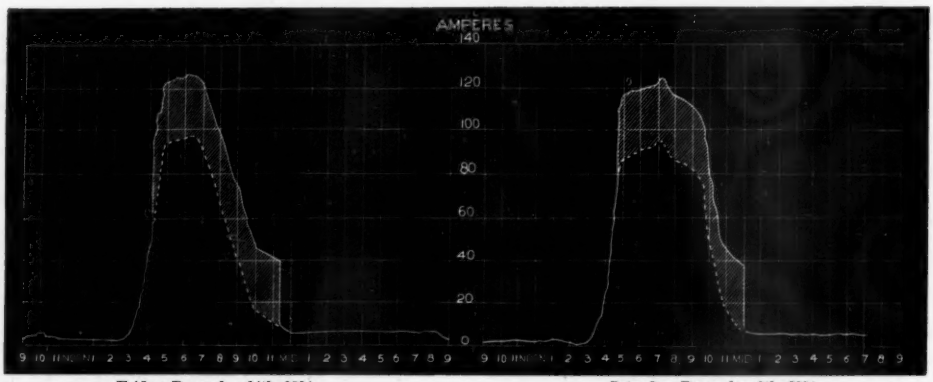
We have so recently described the Portsmouth system, that it is scarcely necessary to do more than mention the fact that the lighting, both public and private, is done by means of Ferranti fly-wheel alternators, the arc lighting circuits being fed by a rectified current derived from Ferranti motor-commutators.

Turning to the figures themselves, we find that the income is made up from two sources, private and public lighting. The corporation pay to the electricity department the sum of £20 per annum for each street lamp, and £14 for each lamp on the sea front, the latter being in use not more than seven months in the year. From this source the electricity works derived £1,127 3s. 6d., while from private consumers they obtained £2,101 8s. 3d., making together the sum of £3,228 11s. 9d. Further on we will give the various items of expenditure; but we will note here the approximate number of units which have been supplied during the six months, which, by the way, is from June 6th to December 31st. It is perhaps unfortunate that during the period under review no meters have existed at the works for continuously recording the number of units that have left the station, but a careful log book is kept and the output is graphically recorded on an elaborate recording apparatus. A meter reading, however, would be interesting only from a distribution point of view, for the units sold for private lighting could only be taken from the consumers' meters. For private lighting, then, 80,000 units have been supplied, 52,374 for street arcs, and 39,034 for street incandescents, the total being 171,408. The method of arriving at the approximate number of units consumed in street lighting is by multiplying the number of hours of burning by the known consumption in watts. The arc lamps have burnt 104,748 lamp-hours, and these multiplied by 500 watts give us the 52,374 units; the street glow lamps have burnt 292,753 lamp-hours, and these multiplied by the approximate consumption in watts, give us 39,034 Board of Trade units. It may be objected that this method of obtaining the consumption of current for the street lamps and the consequent cost is too rough, but it would be difficult to keep any other record of the current consumed in street lighting, for however near one might arrive at the real cost of the arc lamps, it is impossible at present to distinguish the current consumed in the street glow lamps from that used in private glow lamps, both being fed from the same low-tension networks.

It may not be generally remembered that two 32-C.P. incandescent lamps are fixed on each arc light standard, the arc lamps being extinguished at 11 o'clock, the lighting then being done by the incandescents. But as no automatic means of turning on the incandescent lamps is yet employed, it is necessary to send a man round to turn

them on, and though the man rides round on a cycle, it takes about an hour to complete the operation of switching on. As all the incandescent lamps must be alight before the arcs are put out, the arrangement must, to some extent, tell against the cost of street lighting. Therefore, when we take this fact into account, as well as sundry others which will be mentioned, the working results are not only encouraging, but we venture to think that they are without a parallel in corporation lighting. Before we pass on to consider the low cost per unit sold, we should like to mention that, to arrive at a fair account of the six months' working, we ought not to omit to state that the interest and sinking fund, which is £1,640 19s., really makes a loss on the half-year's working of £184, the revenue being as we have already said.

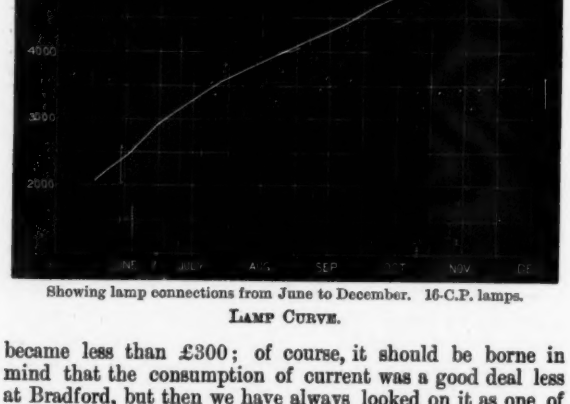
Income	£3,228	11	9	Expenses ...	£1,773 0 0
Loss	185	7	3	Interest on sinking fund ...	1,640 19 0
	£3,413	19	0		£3,413 19 0



Friday, December 14th, 1894.
Full line shows total load. Hatched portion shows the load due to arcs.

Saturday, December 8th, 1894.
Full line shows total load. Hatched portion shows the oad due to arcs.

It is quite likely that the foregoing may be inaccurate up to £30 or £40, but in the main it fairly represents the six months' working. To show a mere loss of £184 when practically everything is paid, after such a short period of working, is really excellent. Bradford, with its good management and rare economy, had a loss in the first half-year of £1,079, and it was not until the fourth half-year that the loss



Showing lamp connections from June to December. 16-C.P. lamps.

LAMP CURVE.

became less than £300; of course, it should be borne in mind that the consumption of current was a good deal less at Bradford, but then we have always looked on it as one of the best managed of corporation works, so the comparison is, perhaps, not so very unfair.

The cost of generation and distribution per unit is, however, the most startling feature about the Portsmouth figures. Briefly, it is as good as anything that has been done in any alternating current station. It seems almost incredible that a station should in the first half year of its existence produce and distribute a unit of electricity for 2·3d.

The following were the principal items which we extracted from the corporation books:—

		Per unit.
Coal	£499 2 7	·69d.
Oil, waste, water, sundries, and carbons	278 18 11	·33d.
Wages and salaries	862 1 10	1·20d.

Other items make up the total to about £1,773.

It should be pointed out that the sum put down for coal includes about 80 tons in stock, and the sum for oil includes about £10 worth in hand. We shall not, however, make any reduction, preferring to keep the amount as it appears in the corporation books; the coal and oil bill also include coal and oil used during the exhaustive tests made before and after the works were opened. Still, keeping them, however, as above, the cost of coal is extraordinarily small. Compared with two or three of the best companies the result is interesting:—

	Output in units.	Cost of coal.	Oil, waste, &c.	Salaries.
Portsmouth ...	171,408	·69	·33	1·20
Newcastle-on-Tyne	360,467	·63	·18	·77
City of London Co.	941,646	·92	·54	·84

How is it done? This is a question that will occur to many; a partial solution may be found in the load curves, two of which we give; it will be there seen that an exceedingly fine load comes on the station about 3 o'clock, and lasts some considerable time. We cannot, however, ignore the fact that the results must be, in a great measure, due to the high efficiency of the plant. It goes without saying, that when it becomes necessary to start the large machines—which should be when the heavy load comes on—they should always start with a good load, due to the combination in one machine of public and private lighting. It is to the credit of the Ferranti 212-unit machines that they have been doing light day loads, owing to the partial derangement of the condensing plant of the turbo plant, which was primarily intended for the day load. We can congratulate everybody concerned. Alderman Ellis is especially to be complimented on the fine result, as well as Mr. Price, the engineer. The results must be also most gratifying to Messrs. Manville and Garnett, the consulting engineers, as well as to the Ferranti Company, Portsmouth being their pioneer slow-speed alternator and rectifier station.

THE HEATING POWER OF SMOKE.

A LEAFLET has been issued by Mr. R. R. Tatlock, F.R.S.C., F.I.C., F.C.S., the City Analyst of Glasgow, which deals with the smoke question. He combats the impression of some people that black smoke is a proof of great loss of fuel. It is, unfortunately, too true that mere blackness of smoke is not in itself evidence of serious loss—the weight of black carbon in a mile of smoke is by no means great. We think, however, that Mr. Tatlock has gone upon a wrong tack in computing the heating power of the solid and the more volatile constituents of coal. Thus, in a weight of 100 of dross there is given 37·63 of gas, tar, &c., and 49·97 of fixed carbon, the remaining 13·40 being water and ash, &c. The heating power of the solid carbon is given as 6·49; that of the gas, tar, &c., as 1·16, and he goes on

to say that calculated according to "Playfair's well-known formula," which was practically tested on coals intended for the Navy, the evaporative power of 1 lb. of fixed carbon is 13 lbs. from and at 212°, while 1 lb. of gas, tar, &c., will only evaporate 3·1 lbs. of water from and at 212°. Now, we do not know just what amount of &c. there may be in a pound of gas, tar, &c., but we are fairly assured that this statement is not true. We should like to hear on behalf of the gas a word from Mr. Dowson, while, we think, Mr. Holden, of the Great Eastern Railway, would give a very different account of the calorific power of tar. The present writer does not know what Playfair's well-known formula may be, but he does know that the coal owners of Northumberland and Durham, and, later on, the Lancashire and Cheshire Coal Owners' Association carried into practice their dissatisfaction with Playfair's tests of bituminous coals, as made by the Admiralty, and hence arose the Wigan Coal trials, which showed for the Lancashire and Cheshire coals, what had already been proven for the North Country coals, that they were equal to the Welsh coals in evaporative duty. Our author, therefore, is wrong when he says that if the whole of the volatile constituents of the dross above named, be lost, the loss cannot exceed 15 per cent.

The loss resulting when smoke is formed, is probably very often caused by an excessive volume of air, and often is due to a lack of temperature whereby more carbon is liberated against the cold plates. Though the subsequent calculations of the author, which show that the solid combustible matter in smoke can only account for ·74 of 1 per cent. of the total heating power of coal, are also based on the Playfair formula, and, therefore, probably wrong, it is none the less a fact that soot is a small loss, and, indeed it is very generally understood that this is so. Nevertheless, this is no reason for inattention to combustion, which usually results both in black smoke and too much air. It is, however, an argument in favour of a different system of combustion, an avoidance of cold furnaces. Indeed, it is about as rational to burn fuel in a cold cylinder as it is to work steam in a cold cylinder, and, though we are willing to admit that a smoke absorber is better than discharging smoke into the atmosphere, we prefer to believe that smoke should not be made; need not be made in a refractory lined furnace.

As regards the value of tar as fuel, Newbigging states that 50 gallons of tar will carbonise 2½ tons of Newcastle coal, though applied in a very crude manner, and that the same duty can be done by about 360 lbs. of coke; applied by steam jet, however, Holden has shown that tar is more efficient than coke or coal.

Approximately, a gallon of tar contains about 10 lbs. of combustible, the remainder being the water from the originating coal. We know, too, that tar and other liquid fuels must be applied by an atomiser if any really good result is needed.

We should point out that a coating of soot upon the heat absorbing surfaces of a boiler is probably a poor heat conductor, and that where soot is formed, loss ensues, not because of the diminution of the amount of the combustible by a few ounces, but by the action of these few ounces plastered on the heat absorbing surfaces. A formula for evaporative power of fuel that was based upon tests conducted by men who could not secure good results, and therefore fitted formula to their results in place of endeavouring to bring their results into line with chemical facts, is hardly, nowadays, to be used in any argument as to combustion. Mr. Tatlock would have us believe that coal gas and tar have a less evaporative duty than is claimed for cabbage leaves, house cinders, old cans, and dead cats, that were to have been the fuel of a recently much lauded refuse destructor. This latest smoke pamphlet carries, however, its chief sting in its tail, for it appears to have been simply a means of drawing attention to a certain named smoke absorber (? washer), which is said ought to receive attention. We have nothing to say against these apparatus in themselves, but it is unwise to push their interest by tendering half-considered statements such as this leaflet presents. Mr. B. Leistikow, in *Stahl und Eisen*, gives figures showing that 1 lb. of gas distilled from coal has the heating energy of 5·13 lbs. of coal. This is a very different showing from Mr. Tatlock's, and corresponds more nearly with known thermo-chemical figures. On this point, however, we would refer Mr. Tatlock to De Soldenhoff's recent paper before the Brussel's meeting of the Iron and Steel Institute.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

INAUGURAL ADDRESS, by R. E. CROMPTON, M.Inst.C.E., President.

Delivered at the Ordinary General Meeting, January 10th, 1895.

I THINK that I shall interest you most if I address you on electrical engineering from my own standpoint. I believe that I am the first of your presidents who received his early training in mechanical and structural work entirely unconnected with electrical engineering, which at that time meant telegraph engineering. You must, therefore, not be disappointed if I deal with electrical engineering chiefly from the mechanical engineer's point of view, believing as I do that its great development dates from the time when the mechanical engineer first took in hand the design and construction of dynamo-electric machinery. This date is that of the Paris Exhibition of 1878, so that we have had 16 years in which to develop the dynamo, the alternator, the transformer, and the storage battery into their present form. During these 16 years the dynamo, in mere size, has increased 500-fold, its efficiency has increased from 60 to 97 per cent.; from an instrument maker's model it has become a machine which, whether as regards solid mechanical construction or smooth efficient working, will compete favourably with any form of engine or machine tool that has ever left the hands of the mechanical constructor. The modern alternator has been slowly evolved from the original Alliance magneto-electric machine, the transformer from the induction coil, the storage battery from the original Planté cell. When I say that the vast development which has taken place during these 16 years has been mainly due to the labours of the mechanical engineer, I do not in the least undervalue the immense labour of the physicists and of the telegraph engineers who preceded us; on the contrary, it is abundantly evident that this rapid development was only rendered possible by the splendid work which the physicists had already done, laying down so clearly the laws and the co-relation of electromotive forces, electric currents, resistance and induction, and to the admirable system of units which, through the British Association committee, the telegraph engineers had worked out to such completeness, that they now form, with very slight changes, the complete system of modern units that are universally adopted, and I cannot omit to mention the great impulse which was given to the progress of electrical engineering by the invention of the incandescent lamp by Swan, Stern, and others, it is quite certain that, although the development of dynamo plant for arc lighting and for transmission of power would have attained considerable proportions without the assistance which it has derived from the demand for incandescent lighting, yet it would have taken a vastly longer period to have reached its present stage of development.

I am one of those who, when I use the word "electricity," have before me a mental picture of an agency which we use for producing action at a distance, an infinitely flexible connecting-rod by which we can transmit energy and reproduce it at a distance in any desired form. Perhaps the reason why I have formed this mental picture is that I entered on the study of electrical engineering through a very correct process of evolution. Having been previously engaged on a practical application of hydraulic transmission plant, I was, from the time that I first commenced on electrical work, struck by the general resemblance which the flow of electric currents through conductors bears to that of water or other fluids through a system of pipes. It is almost a pity that the actual demand for electrical energy for light-giving purposes preceded that for mechanical power purposes, as the part which electricity plays as a connecting-rod only, is not so immediately evident when it is reproduced as heat for electric lighting as when it is reproduced as mechanical energy in a motor. At a very early stage in the mechanical development of electrical machinery, the mechanical engineer found himself confronted with an entirely new set of problems; he found that the laws which govern the flow of the electric current and the formulæ he had to use were simplicity itself compared with those he had been compelled to master before he could deal with the design of any form of thermal engine, or even deal with the flow of fluids or liquids through pipes, the chief reason being that the electric current is so easily confined—"canalised," as the French call it—in its conductor by its insulation that the losses due to electrical leakage may in most cases be neglected, whereas the losses in thermal engines through the walls of the passages or confining chambers are so great, and form such a large percentage of the whole of the energy, and vary through such very wide limits according to their form and to the materials of which they are constructed, that the calculations involved in any new design are extremely complex. On the other hand, the mechanical engineer found that the necessity for so frequently interposing insulating materials between the various parts of electrical machinery greatly increased the difficulties of mechanical construction. Nearly all insulating materials are deficient in mechanical strength; in most cases they do not maintain their form through any considerable range of temperature, are readily damaged by oil or grease, and do not readily lend themselves to being cut or shaped by ordinary tools. Constructors of electric apparatus have to deal chiefly with iron, copper, and insulating materials.

The improvement in the electric qualities of the first two have been very marked, and we have probably arrived at finality, but we have made but little advance in the improvement of our insulating materials. Probably of all the materials that are available for insulating or isolating the parts of generating machinery, transformers, and distribution appliances, mica is the only one that at all approaches our requirements, and mica is only satisfactory when it can be applied in thin sheets to insulate adjacent surfaces of considerable area. Slate, porcelain, and enamel, when used as insulators, although they can stand considerable changes of temperature without alteration of their insulating qualities, are deficient in mechanical strength, and cannot be readily shaped or cut. Wood, hard rubber, and the various patent materials—such as woodite, vulcanised fibre—although they are more satisfactory as regards mechanical strength, are considerably affected by heat, moisture, and oil or grease. The various slates and marbles are mechanically weak, and, unless protected by enamel, are absorbent, and partially lose their insulating qualities in a damp atmosphere. Attempts that have been made to mould or cast insulating materials out of mica waste or similar substances, cemented together by shellac, resin, or other adhesive materials, have only obtained partial success. In no case has the double requirement of mechanical strength been combined with that of resisting change of temperature or the absorption of moisture. This difficulty in obtaining satisfactory insulating materials has been the chief stumbling-block which makes the work of the designer of electrical machinery so much more difficult than that of the designer of ordinary metal work, where the necessity for insulating the parts does not come in. The improvement of the material that must be used for insulating the distribution system of conductors has been an equally difficult matter. The study of this question was forced upon us as soon as it became evident that electrical energy could be commercially supplied and distributed throughout our streets. The problem has been attacked in various ways. The

various systems of insulation that have been tried can only be tested by time; it will be many years before we shall be able to predict with any certainty as to which systems are likely to survive. It is impossible for me to devote more than a few lines to this interesting question. As you know, the systems of conductors that have been hitherto laid divide themselves roughly into built-in systems, drawn-in systems, and those which use bare conductors insulated by glass or porcelain. Quite recently the attention, not only of ourselves, but of the public, has been directed by several accidents to the dangers attached to electrical conductors laid in the streets. In many cases these dangers are not properly attributable to the electric conductors themselves, but to the presence of gas in the soil through which these conductors pass. Wherever any space exists into which this gas can infiltrate, an explosive mixture may be formed, which may be fired either by an electric spark from the conductors themselves or by contact with a match dropped by a smoker. I think, however, that there is no reason for the public to unnecessarily alarm themselves. In the vast majority of cases where the system of conductors is continuously inspected for traces of gas no accidents of any kind have occurred.

Although I have already stated that electrical engineering is greatly indebted to the mechanical engineer for much of the development that has taken place in recent years, yet in some respects the reverse is the case. The alliance between us has not been wholly productive of benefit to us. An electrical engineer nowadays has to grasp the whole subject of the production and distribution of electrical energy from the energy contained in the coal to the point at which it is delivered to the consumer. As regards a very large portion of the plant he has to use, the electrical engineer has had to adopt the appliances already sanctioned by the mechanical engineer: I allude to the boilers, steam-engines, and to the motive power generally. When the electrical engineer called for a motive power on a large scale, he found ready to his hand the experience of those who had equipped the great factories of the manufacturing districts of England; and these gentlemen have had a considerable hand in the design and application of the motive power we use, and I am afraid that in many cases the combination has not been altogether a paying one. Previously to the introduction of power houses for the generation of electrical energy, the large mill-owners were the principal users of power in England, and it is to their requirements we owe the developments of the Lancashire boiler and the refinements of the large slow-moving engines that are always found in such factories. These gentlemen are perpetually reminding us that in order to obtain the maximum of economical success we have only to copy their practice, and that anything that differs from their practice is wrong, and I am afraid a very considerable number of electrical engineers, particularly the younger members of our professsion, have been considerably swayed by these utterances. I feel very strongly, however, that it is time to speak on these matters with no uncertain voice. The conditions under which we work our engines, boilers, and other motive-power plant for electrical supply purposes differ so widely from the conditions of motive power for driving factories that their experience is of little or no value to us—in fact, it is in many respects misleading; and I take it to the credit of electrical engineers that it is we who have been mainly instrumental in developing the newer types of engines and boiler plant which are now largely used in our supply stations. I think that few will doubt it was the exigencies of electrical engineering that led the late Mr. Willans to carry out his extensive series of experiments on the economical use of steam which has so revolutionised our ideas on the subject. If it had not been for the conveniences for accurate measurements which the dynamo and electric measuring instruments offered, Mr. Willans's experiments could never have been carried out to the convincing degree of accuracy which he attained. I think, from this and from other causes, that we electrical engineers are already beginning to return to the mechanical engineers some of the benefits that we received from them. I am sure that the considerations of load factor and all similar matters, which have been found of great importance to electric supply engineers, will be found to have almost equal importance in the matter of waterworks, gasworks, and many other industries. In a word, I believe that the studies which we have been compelled to pursue in order to investigate and deal with our electrical difficulties will prove to be of considerable service to the engineering world in general, and that the engineering world in general will gradually become more and more intimately connected, so that eventually some part of the training of every engineer who deals with constructive works or supply works of any form, will be an electrical one.

Not the lightest of the duties of the modern electrical engineer is that of educating the public in the use of electrical energy. This process, which we in this room call the improvement of the load factor, is a matter of such importance to you all that I need not apologise for dealing with it at some length. We not only desire to have the output of our generating station more evenly distributed throughout the 24-hour day, so as to fill up the valleys and reduce the peaks of our daily diagram, but we also wish to improve the summer diagram as compared with the winter one. The problem of satisfactorily and economically working the daily diagram may be, to some extent, dealt with by improvements in the storage of electrical energy; but, even if we were in possession of as satisfactory a system of electrical storage as the gas companies possess in their gasometers, it would only help us to this point. The great disparity between our winter and summer loads is due to our geographical position, and will always exist so long as the major part of the energy we supply is for lighting purposes, and the obvious remedy is to encourage its use for motive power and for heating and cooking; and to me at the present time it appears a far easier matter to educate the public to the advantages of using electricity for heating than to induce them to use motive power to any considerable extent. For this reason I have persistently advocated the perfecting of electric heating and cooking appliances. This matter has not been much understood even amongst electrical engineers themselves. For a long time the opinion was very generally held that the energy required for electric heating is so great that its cost would be prohibitive. At first it was not seen how effectively electrically heated appliances could be used for cooking purposes, how large a proportion of the heat units would be usefully employed in cooking food, and how small a percentage would be wasted in heating surrounding air. Now that this result has been obtained, and that cooking operations on a considerable scale can be carried on in an ordinary sitting room without perceptibly raising the temperature of the air of the room, it will be seen that electric cooking is certain to obtain popularity in hot climates, or in summer, or in small tenements at such time when the lighting of fires and the waste heat from these fires is not only unnecessary but actually objectionable, and this even if the cost of the electrical cooking be considerably in excess of that by other means. At any rate, we may assume, if these expectations are only partially realised, that there will always be some sale of electricity for these purposes, and that the addition to our load diagram for such use will take the form of adding to it a parallel strip commencing from 7 o'clock in the morning and ending at 11 o'clock at night, as I do not think there is anything in the condition of electric cooking to warrant anyone in thinking that the demand for energy for this purpose will be confined to the period immediately preceding each meal-time. The use of electricity for heating will be probably confined to the partial heating of rooms or parts of rooms which are required to be occupied for short periods or for the airing or warming of clothes or linen, and such use is also likely to be confined to the same hours as I have given for cooking.

(*To be continued.*)

The Northern Society of Electrical Engineers.

Inaugural Address of Mr. Henry Edmunds.

At the meeting of this institution on Friday last, Mr. Edmunds, in his presidential address, said: In some quarters the question is asked, "What need is there for such a society as ours? Have we not already the Institution of Electrical Engineers and other kindred societies?" The answer may be considered chiefly geographically. It is difficult for men living in the north to attend regularly the meetings held in London; and the mere reading of the proceedings of the London meeting does not compensate for the absence of personal contact and debate. This society is not an offshoot, nor an affiliated member of the Institution of Electrical Engineers, but an independent body, composed of men having kindred interests and tastes, and many of whom, like myself, happen to be members of both the Institution of Electrical Engineers and the Northern Society of Electrical Engineers. Therefore, as an independent body, we must carefully consider what our aims, interests, and objects are, and see if they differ in any way from those of other institutions. If our objects are exactly alike, we may be said to be in competition; and if in competition, we must naturally try to excel and do better than those we compete with. I think a little competition among societies may be healthy as it is in commerce. Now, we are a formed society, one year old. We have 125 members, a balance at the bank, and are financially sound. Our society is respected so far as it is known by kindred societies, and its papers and discussions have been published and commented upon by the technical journals; and now, at its first birthday, it may be said to have justified its existence. But what is its future going to be? That brings me to the most serious and important part of this, the first, Presidential address. If we wish to live, grow, and be respected, each member must contribute his own individual effort. Each one must feel himself honoured by being elected a member of this society, rather than consider he confers an honour to the society by joining it. I speak in this way, as I fear that at some of the meetings during the past year this idea may have been overlooked. It is probably excusable, when we consider the youth and consequent inexperience of the society; but as we grow older we must grow wiser and stronger; we must consider what the aims and objects of this Northern Society of Electrical Engineers should be. We may divide these objects into (1) the practical and technical, and (2) the social. I put practical first, because in looking around me I see so many men who are interested in the everyday work of constructive electrical engineering rather than in the pursuit of scientific research. We may further divide our engineers into two classes, consulting and constructive. A word to the consulting engineer may be well brought in here. In the first place, the profession is an important and useful one. It is the duty of the consulting engineer to plan out, design, and to guide those who have no technical knowledge of their own. Corporations and individuals employ the electrical engineer in the same manner as they employ their architect, their gas or water engineer. But our profession is a young one. During my connection with it, which dates back from 1877, I have seen the gradual falling into rank of men who in 1877 were unheard of and unknown. The electrical engineer of that day was essentially a telegraph engineer, and his ideas, with few exceptions, were limited to the working of land or submarine telegraphy. I often think that the rapid advance of electrical engineering was retarded in consequence to the limitations to the mechanical and engineering side of the question, which limitations were set by men whose knowledge was mostly confined to magnets covered with fine silk covered wire, and currents that could not vibrate the indicating needle of a modern central station ammeter at zero. I would not for one moment reflect on the gentlemen of 1877, but only wish to indicate to you that the electrical engineer is a creation made since then. He has had a very long childhood, and like the rest of us, has had a great deal to learn and

unlearn. Naturally, when work was placed in the hands of the new engineer when he became consulting rather than constructive, he was apt to please his vanity, and try to justify his existence by changing every dimension and detail he possibly could in existing machinery and appliances. And it did not end with merely painting the machine another colour; but each engineer varied the speed of his dynamo, the pressure of his mains, the type of engine which should drive, and the thousand and one details which, while they might not interfere with the result of the whole, have had a very serious interference with the advance of the electrical industry. In England, I think, we have been as much cursed with amateurish engineers as they have been blessed in America with the absence of them. I recollect when I first met Mr. Brush in Cleveland, U.S.A, in 1879, and saw his very plain, but useful arc lamp, I thought it might be considerably improved, and told him so. He looked at me and said, "It works; what we have to do is to sell them." And they did sell. I was instrumental in the introduction of that system into England. Many people came to see our first installation in Hatton Garden, and then at the Liverpool Street railway station, and nearly everybody said how much prettier they might make the arc lamp. Engineers and others who were asked to tender for building the Brush plant and apparatus, in nearly every case had some suggestion to make for the alteration of dimension and detail, in order to suit each individual whim. The result was that we were much longer in making progress in England in the introduction of the arc light than they were in America. Though I do not wish to infer that this was wholly attributable to this cause, yet it was to this among others. Now, what we want in a consulting engineer is a man who can recognise, first, what is best in the market, best for actual merit, and most suitable for his requirements. A man who can guide those whom he advises in their selection of the best thing for the work to be done, and who will be content to leave matters of constructive detail in the hands of honest manufacturers, whose interest and profit shall lie in making a good thing, rather than in producing some type or variation of design, of which he practically makes only one (and that an unsatisfactory one), instead of many which can grow each in quality through experience in manufacture, and where there is a margin of profit which, as in many manufacturing operations, is larger in consequence of numbers and output. My remarks refer, of course, to the immature engineer, and, naturally, can have no reference to individuals present. Our consulting engineer can be of great help to us if he works conscientiously. He will see that what is undertaken by the contractor is carried out efficiently and well; and I also think it is his duty to see that not only do those who employ him get good value for their money, but also that those he employs get a reasonable margin of profit on their work. This brings me to another and very important point. We find all around us towns, corporations, and companies that are going in for the public supply of electricity. We find a huge new industry in which thousands of pounds of capital are invested. Many of the most advanced minds are at work in developing mechanical and electrical details, and yet we find that, with very few exceptions, nearly every manufacturer who tenders competitively for work says he will be practically without profit if he gets the contract. Now, something is wrong in this. I admit that competition (which, after all, cannot be prevented) has a great deal to answer; but I think on the other hand that many of our consulting engineer friends (and, as I said just now, it is their business to see, they being disinterested themselves) should see that both parties to the bargain, those who buy and those who sell, are taken reasonable care of. It is a curious fact that there are large corporations around us, that have plenty of money (that they can borrow at a low rate of interest), buying electrical machinery and plant that barely pays a profit to anyone concerned. And yet these same corporations, acting under the advice of their engineers, would be perfectly willing to pay a fair price. In many cases I have known that engineers' estimates are allowed that would have given a reasonable working profit to all the contractors and undertakers; but these were undercut by the competing firms. I merely mention this here in connection with our consulting friends, who, I am sure, can be of great assistance to us, but the fault is not theirs. Now, we will pass from the consulting to the constructive engineer. In this class we include both manufacturers and installers; and we may consider these gentlemen from both an electrical and mechanical standpoint. In electrical engineering of to-day—I mean where we are converting heat energy into electrical energy through the medium of dynamos and generators—the mechanical engineer plays an important part; and I am glad to see that the society has among its members many gentlemen who may be said to belong exclusively to the mechanical side. They must, however, in order to justify their membership of a society of electrical engineers, see how closely the union between the electrical and mechanical is growing. It must not be sufficient for them to say that they make an engine that can run at a given speed, and that such engines as they have built have been working in connection with Lancashire boilers in our cotton and other industries here for the last 25 or 30 years. I do not suggest that many engineers say this to-day, but I remember in the early days of electric lighting the man who made a small portable agricultural engine said he had got everything that was required for our purpose; and I remember what difficulties we had in getting these people to see that the requirements of a mechanically driven dynamo were different from that of driving a threshing machine. To this engineer, they both went round; and I remember that a man would say that his engine could do such and such work, and could certainly drive that bit of a thing—the dynamo. He would come and watch his engine, the stoker perspiring, the water running down, and the steam running down still quicker; and he would stand and wonder where on earth the power was going to. We have left these days, however, and the mechanical engineer is awaking to the fact that perhaps the biggest field he will have in the future will be in connection with electricity. In a district like this, where thousands of engines are used daily for driving mills, with their miles of shafting and belting, manufacturers are beginning to wonder why they should use such huge engines at times when their loads are light and only part of their works are running, and they have to lose so much in unnecessary shafting and belting, friction, &c. In many places I am glad to say that following the electric light plant has come the electrical distribution of power plant. Electric motors are taking the place of shafting, and wires the place of belting, and I advise our engineer friends to look well to this outlet for their industry during the coming period.

(To be continued.)

CORRESPONDENCE.

Muirhead v. The Commercial Cable Company.

In the article under the above heading which appeared in your issue last week, the following is embodied :—

"We have it on excellent authority that the supposition that accurate balancing can be obtained by the rheostat in question is an absolute delusion, and that, as a matter of fact, the arm of the rheostat may be turned to any position without upsetting the balance and disturbing the signals; its existence does no harm, but for any particular good that it does it might as well not exist."

I quite agree with the writer of this, that it is very unlikely a balance by means of the rheostat at the apex of the bridge alone can be obtained; it is generally necessary to use it in combination with another adjustment, viz., either a leak put at some point along the artificial line, or a finely sub-divided adjustable condenser placed as an auxiliary to the condensers in one arm of the bridge, whether on the cable side or artificial line side depends upon the direction of the inequality of the balance which it is desired to compensate.

According to my experience, the effect of the adjustable resistance at the apex of the bridge is vibratory, and will only improve the balance up to a certain point, it being always necessary to smooth down and perfect by other means.

With regard to the statement that the arm of the rheostat may be turned to any position without upsetting the balance and disturbing the signals. The only condition, it seems to me, in which the effect on the balance of moving the arm of the rheostat placed at the apex of the bridge from one extreme limit to the other would be *nil*, is on a short cable, say, 500 miles or less, when the instruments are comparatively unsensitive, the condenser capacity in the arms of the bridge comparatively small, say, 30 microfarads or less, and the total resistance of the rheostat employed not more than 30 ohms. In such a duplex installation the effect of the rheostat on the balance would probably be *nil*, but in the duplex installation of an *Atlantic* cable, say, from Waterville to Canso, the movement of the arm of the rheostat from 0 to its highest resistance (presuming all other things remained constant), according to my experience, would materially affect the balance. On a long cable the rheostat at the apex of the bridge, having a total resistance usually used, has a considerable effect on the balance when altered to any extent, but whether it is a good and dependable adjustment is another matter.

It has been proved that quite as good balances can be obtained and maintained without it; since this is so, as every connection in a duplex installation increases the chance of leakage, and consequent instability of size of signals or perfectness of balance, it most certainly seems better to do without it. I cannot agree with the writer of the paragraph quoted above that its existence does no harm; if it is not useful, it must tend to be harmful, for the reason just stated, and should be cut out.

In my communication, which appeared in your issue of May 4th, with reference to the above case, I pointed out undue importance had been attached to the efficacy of the rheostat placed at the apex of the bridge as an adjustment. Since then this has been conclusively proved by Mr. Ward's letter, which appeared in your issue of June 15th last, in which he states the rheostat had been entirely dispensed with on one of the Commercial Company's Atlantic cables.

I also pointed out that the statements made at the trial by Lord Kelvin and Prof. Bottomley, that the sum of the resist-

ances in the arms of the bridge must remain constant, for which purpose this particular form of rheostat (described as a readily adjustable resistance) was employed by Muirhead, was in practice incorrect, as a resistance box which is also readily adjustable (see sketch, Electrical Review, Vol. xxxiv., page 514) could be used with success; in this box the sum of the resistances in the arms of the bridge can be altered at will within the prescribed limits, and even smaller increments and decrements than is possible with the Muirhead rheostat.

Geo. Herbert Bailey.

Are Birds on the Wing ever Killed by Lightning?

I have been asked to express my opinion whether birds flying in the air are ever killed by lightning.

My opinion is that a lightning discharge may occasionally cause their death, but simply from their being accidentally in the line of the path of discharge or in very close vicinity to it.

Electrical conduction, according to the views I hold, is primarily atomic—in other words it involves the breaking down of the molecules that compose the path of discharge. I regard an air path as an electrolytic conductor whose conductive resistance is determined by the strength of the cohesive force that binds together its atoms and molecules.

A lightning discharge is a violent explosion, a bursting up of the molecules composing the path of discharge, followed immediately afterwards by a re-arrangement of the atoms and the formation of altogether new molecules.

A spark between the + and − poles of a Wimshurst machine may be taken as representing fairly a lightning discharge in miniature.

The machine I possess is a small one, and capable of breaking down an air path of nearly five inches, but the average length of the sparks gives under ordinary atmospheric conditions ranges from $3\frac{3}{4}$ to 4 inches.

Now when the poles of the machine are separated to the practical limit of the breaking down potential, what I observe is that the sparks rapidly succeeding one another do not select the same path, and the actual length of the sparks, and, consequently, the number of air-molecules broken down at each discharge varies. Having made this observation, I place a metal plate in the air space dividing the two poles of the machine, but not actually in a direct line. This metal plate forms a conducting bridge, and I so arrange matters that, if the discharge avails itself of the metallic bridge, the length of the air space through which the sparks occur is a little less than it would be when the metal plate is removed.

Under these conditions I observe that the sparks for the most part pass from the one pole through the air to the one side of the metal plate, and from the other side of the metal plate through the air to the opposite pole, but every now and then the discharge ignores the metal plate altogether and chooses an air path of greater length, and which one would suppose must oppose greater conductive resistance.

I am disposed to think that the reason that the discharge selects a longer air path instead of availing itself of the metallic bridge arises in part from the greater inertia resistance which is opposed by a metallic path as compared with that of gaseous matter, but be this as it may, the metal plate in the air space as described, may be regarded as not unfairly representing a bird flying in the neighbourhood of the air path through which a lightning discharge occurs.

The bursting up of air molecules forming the conductive path of a lightning discharge develops intense heat, and the air molecules in the immediate neighbourhood become expanded violently and possibly also electrically repelled, and if a flying bird were in the vicinity at the time he would be probably carried along with the expanded air, and it is conceivable, I think, that if very close to the line of discharge the bird might be killed by the concussion.

S. Alfred Varley.

The Incandescent Gas Light.

As a subscriber to your widely-circulated paper, and one who has had experience in incandescent gas light as well as electric lighting, I feel bound to refute many of the statements, disparaging to the interests of the former system, made in your article of the 4th inst., dealing with Welsbach's patent. Unfounded and biassed accusations I have heard time after time from interested electrical contractors, but never yet have I heard one statement, in contradiction to the literary matter set forth by the promoters of Welsbach's patent, fairly or honourably substantiated when actually put to the test by uninterested parties. It is no object of mine to advertise the Incandescent Gas Light Company's goods; but I do like to see an adversary to electrical industry—for such is, undoubtedly, Welsbach's patent—met fairly, and not hit below the belt.

Firstly, to find fault with the colour is as bad as the pan calling the kettle black. Is it possible that any person pushing an article upon the market would not endeavour, as far as possible, to suit the tasteful peculiarities of the public? Chimneys and shades are, to my knowledge, made in every possible colour and design. How is it possible for a man who has his light enveloped in a ruby chimney, surmounted with a ruby-etched globe, to complain of a "greenery-yellery" light, quite "intolerable," and "reading by it painful." Such argument is frivolous.

Secondly, I maintain that with a very ordinary amount of care, mantles will last about 1,000 hours. The "Ediswan" lamp lasts a similar time, while their respective costs for renewal are 1s. 3d. and 1s. 9d.

Thirdly, hygienic principles show that incandescent gas light is not detrimental to health. A special analytical and sanitary commission on Welsbach's system, under the auspices of the *Lancet*, report, in their journal of the 5th inst., that carbon-monoxide is totally and absolutely absent. This lengthy report is worth the perusal of everyone.

Lastly, I am almost solely indebted for the information respecting Welsbach's light to persons who have adopted the light throughout their premises, and have given it every possible trial. The light has, without doubt, come to stay. The business returns and dividends of its promoters are proverbial. Such a hold has it made on the public, that "no bluebottle is going to snuff it out or wreck it," nor even a plague of locusts, to keep up the simile, will disperse it. Throughout the kingdom lately I have seen it used to advantage in shops, factories, warehouses, theatres, public halls, streets, hotels, and dwelling houses. Happily for electrical interests, the glow lamp had six years start in the field, or one of the most interesting industries of modern times would have now been, to all practical purposes "*non est*."

E. H. Welch.

[We simply refer our correspondent to our leading columns.—Eds. Elec. Rev.]

Higher Voltage Lamps for Central Stations.

I am glad to see this important matter discussed in your columns, and consider a few remarks on our experiences here may not be without interest.

In a report to my committee early in 1893 on the subject of extensive alterations, I recommended the subsequent use of 230-volt lamps in preference to the adoption of a five-wire system of distribution, and the rearranging of our system was eventually carried out in accordance therewith.

I found no difficulty at the outset in obtaining 16-C.P. 230-volt lamps from several makers at a reasonable price, viz., 1s. 1d. each, and some as low as 10d. Exhaustive tests reduced the makers of first-class lamps down to two firms. After burning quite a number of their lamps some 3,000 hours without a single breakage, I considered the success of my scheme was assured. The lamps did not require more than an average of 3·2 watts per candle-power, and at the expiration of the tests little or no carbon had been deposited on the bulb; indeed, both filament and glass looked as if scarcely used. As soon, however, as the firms entrusted with the wiring of premises placed orders for lamps, the most unexpected and vexatious delays began to crop up. Reiterated inquiries elicited replies to the effect that the lamps were being flashed, &c., and would be delivered shortly; but as the shortly extended over six or seven months, it became necessary meanwhile to use the old voltage lamps, and places using 230-volt lamps have had to be renewed by 115-volt. Quite recently, within the last few weeks, I have been able to obtain a quantity of high voltage lamps from a new

source, and they are likely to compare favourably with those already referred to.

Surely the disinclination hitherto shown by the makers to furnish lamps of this class portrays a want of foresight. At Bradford the capital sunk in mains represents some £35,000, and we have about 20,000 incandescence lamps (omitting arcs). What central station engineer would not gladly renew all his customers' lamps at one stroke gratis to obtain doubled capacity for his mains, with only one half the fall per cent. at the customers' terminals, better regulation, increased revenue (due to uniform voltage at the lamps), greater popularity of the light, and very considerably reduced waste of energy in transmission? If the lamp makers would combine with the engineer to achieve this end, a reduction in price of current would speedily follow, with a correspondingly vast increase of business in the lamp making industry.

It should not, however, be overlooked that there is a difficulty in dealing with arc lamps. No small consumer would care to burn four or five arcs in series, when two would answer his purpose. Maintaining one side of the three-wire system at 115 volts to suit the arc lamps, and the other side at 230, is out of the question, because arcs, being mostly outside premises, are lighted considerably later than the incandescence, and in some cases only on special evenings, hence a difficulty in maintaining uniform balance on the system would present itself. It would therefore appear that a special circuit for arc lamps, all in series, metered by a simple time switch, would be advantageous; but such a scheme could not readily be carried out in existing works. Cheap lamps, burning two small arcs in one globe, could be used, and the light therefrom would be devoid to some extent of the flicker, owing to there being two arcs in the one globe.

It is to be hoped that lamp manufacturers will endeavour to keep up with the requirements of the electrical industry, and place freely in the market a class of lamp that must, in the end, supersede all others.

Sydney W. Baynes.

Bradford Corporation Electricity Works,
Bradford, Yorkshire.

The Design of Large Alternators.

It has interested me, and may interest Mr. Armstrong, of Schenectady, also, to learn that the London Electric Supply Company, after many years' experience with coreless disc alternators, have just ordered another one of 1,000 kilowatts output, thus confirming my contention that coreless disc dynamos are perfectly successful, and much superior to the horrible designs embodying gigantic rickety masses of laminated iron stampings.

The design of large alternators may present no enigmas to the "smart Alecks" on the other side of the Atlantic ferry; the actual machines, however, seem to present some room for a little variation in design, if only for the sake of a little experience with a design differing from the usual run.

We may look forward to an American inventor in a few years discovering the coreless disc armature, and extolling its virtues, in the same way they discovered the constant current dynamos years after they were abandoned here.

Rankin Kennedy.

Edison Phonograph Motor.

Can any reader give me particulars of the "Edison phonograph *motor*." Dimensions, size and quantity of wire required? Can correct castings be procured? Instructions how to wind fields and armature, and all information for making this motor will be gratefully received.

Motor.

Resistance of Alloys.

Would any of your readers oblige me with information as to the conductivity, or the resistance of alloys, especially of copper. Also, what law the resistance of alloys follows, as compared with the component pure metals.

E. L. Andrews.

[The specific resistance of alloys does not follow any known law, *i.e.*, it cannot be calculated from the specific resistance of the component metals. A list showing the relative resistances of various copper alloys will be found on page 82 of Kempe's "Electrical Engineer's Pocket Book." Perhaps, however, some of our readers may be able to give some further information on the subject.—Eds. Elec. Rev.]

Explosions and Means of Remedying.

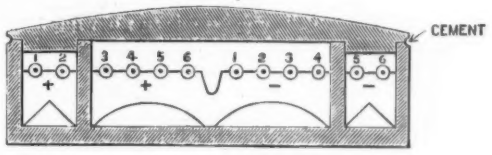
The following are my views in relation to the construction of conduits for electric light mains, which, I hope, will not frighten our electrical engineers, but rather induce them to think seriously over the business, and speedily arrive at some standard system.

1. I condemn the present system of bare conductors, and the sooner an entire reconstruction, on a proper principle, of the conduits is made, the safer for the lives of the public.

2. We must always consider that a conduit, no matter what it is made of or how carefully the work is executed, will admit gas and water, but our aim should be to construct it as perfectly watertight as possible.

3. It is essential for a conduit to have side chambers, however small, to admit gas and water, and that a blow of compressed air be sent through the entire thing, *i.e.*, inner and outer chambers, into the manhole once a day, to eject any gas or water that may accumulate.

Fig. 1.



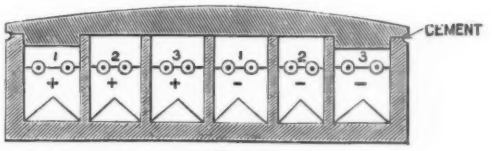


Fig. 2.

4. It is essential to have every manhole ventilated by erecting an upright ventilator on the curbstone.

5. A conduit should be constructed with a cover (not all in one piece), and the cables laid therein, and thus avoid friction and grit.

Figs. 1 and 2 represent, perhaps, a simpler and less costly conduit to that suggested in 1890, which might be made of iron, enamelled inside, or entirely of stoneware.

The figures, 1, 1, &c., show the positive and negative of the same two independent mains, so that a short circuit cannot occur, and thereby no explosion.

I candidly feel that such a conduit is well worth a protection, but rather than delay ventilating this important subject, I give my suggestions to the world.

Trusting that these notes will be of some interest to your readers, and apologising for length of same,

Arthur E. Gilbert, A.I.E.E.

Explosions in Electric Culverts.

The numerous explosions which have occurred in electric culverts lead me to draw attention to the necessity of accurate and delicate testing for inflammable gas in the air of these culverts and street boxes. After a recent explosion of this kind in the metropolis, careful tests were carried out by Mr. Beverton Redwood's apparatus, which involves the application of the hydrogen flame to gas testing. I have shown that this flame surpasses all others for accurate and delicate gas testing, and I was, therefore, quite prepared to hear that the presence of 1 per cent. of gas was easily detected by means of this apparatus when other detectors had failed to find any gas at all.

It does not seem to be generally considered that coal gas is more or less completely deodorised by passing through soil, as

is shown by the strong smell which it imparts to the soil through which it has passed. It has been stated on good authority that this loss of smell is, in some cases, complete. Hence the statements freely made that coal gas must be absent from the culverts, if this gas is not smelt, cannot be held to be conclusive; and it becomes necessary to apply an accurate detector, such as Mr. Redwood's apparatus, to establish the fact whether gas is present or not.

It may be added that this hydrogen flame detector, as applied in a safety lamp or in the apparatus above referred to, also easily shows the presence in the air of a proportion of carbonic oxide, or of "water gas," which, according to the report of the Russian Fire-Damp Commission, is below the quantity poisonous to man when inhaled.

Frank Clowes.

University College, Nottingham,
January 15th, 1895.

Since the announcement of the gas explosions in underground electric main culverts or ways, I have been waiting a letter from Mr. Harman T. Lewis, our first Hull Borough electrical engineer, drawing attention to a system of perforated iron lids on our pavements, placed over porcelain pits outside, but communicating by a pipe with our culverts, which he invented for us in Hull to prevent gas accumulation in our bare copper strip culverts.

Seeing that he left Hull to undertake the responsible task of initiating the electric light station at Wolverhampton, I suppose he has not had the opportunity of knowing how very successful we have found them in Hull.

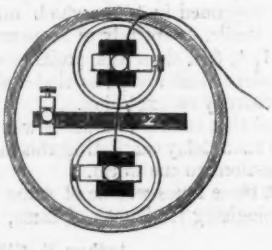
I am glad, however, that Mr. Jenkinson, who superintended their laying for Messrs. Crompton, has drawn attention to them through your columns. It therefore only remains for me to strengthen his opinion by saying they have in every way been successful. They have admitted no water to the culverts, and only the other day I heard again from our outdoor foreman there was no trace of gas, and no fear of explosion near them.

W. Holder,
Chairman Hull Electric Light Committee.

January 12th, 1895.

Primary Batteries.

With reference to Mr. Paine's letter on page 45 of this volume, may I point out that in the two-fluid chromic cell, illustrated in his fig. 3, a great amount of room is provided for the chromic solution, and very little for the sulphuric solution, which must occupy a greater volume on account of the sulphate of zinc to be formed in it, if crystallisation in the cell is to be avoided.



For some years I have used the somewhat similar arrangement indicated in the annexed plan, a flat zinc being placed between two common round porous pots, in a round outer cell, two carbon blocks being used. With fresh strong solutions in two such cells of ½-gallon size, in series with ·215 ohm resistance, a fairly steady current of 10 ampères is obtained.

T. H. Muras.

Submarine Cable Grapnels.

The modification of Mr. Claude Johnson's new collapsible grapnel, suggested by your correspondent "XXX." is undoubtedly very ingenious; but, assuming that a grapnel of the construction suggested by him enters a narrow passage—so narrow that, say, two of the springs come in contact with the rock before the prongs do—the tendency will be the reverse of the desired effect, *i.e.*, the pressure on the springs will force the points of the prongs outwards, giving them a tendency to hold on to the rock.

It also appears to me that the conical shield is far preferable to the separate bar springs for each prong; the separate pieces, by reason of the salient angles they present to the rocks, increasing the chances of the grapnel becoming "fouled," and the springs themselves being unprotected, would be liable to lateral displacement and breakage.

These points will, I think, be quite clear on reference to the illustrations in your issues of the 4th and 11th insts.

P. C. G.

January 14th, 1895.

Young Engineers.

On Thursday last, being at Loughborough, I took a specially early train to town in order to hear Mr. Crompton's presidential address. The theatre was well filled, but I got a seat all too easily; we are a young institution, and the bulk of our members and associates are young, but it is time they recognised that to such men as Mr. Crompton they owe their electrical existence.

We are now in the happy position of having two years in succession a pioneer president.

Mr. Siemens brought with him all the weight and the tradition of the name of Siemens, coupled with his own personal power as a prime mover of the great electrical industry.

Mr. Crompton brings his own record, of which he may well be proud; he has stood by us in good report and evil report; like a true British admiral he has nailed his colours to the mast, and is prepared to sink or swim with his chosen crew. Where should we have been to-day but for such men; there are always plenty to criticise, plenty to tell us how this or that might have been done better, but there are few who come forward and stake their fortune and their reputation on the success of their principles.

I listened to Mr. Crompton's address with great interest and with intense admiration for the zeal and ardour (to which it bore witness) of his endeavour to improve the load factor of our central stations, for on this question hangs the future of the great body of our rising electrical engineers; the more we can flatten the load curve the higher will their salaries rise, and the sooner they realise this the better.

There was one reference to the junior members which I cannot fully endorse. Mr. Crompton referred to the danger, which he estimated as a very grave danger, threatening the progress of the electrical industry, arising out of the fact that a large proportion of our engineers in charge of the construction of works and the running of plant are young and inexperienced. On this particular subject I have probably a wider personal knowledge than even Mr. Crompton, and I have no hesitation in saying that in respect of this danger we have passed the top of the curve. I notice a very marked improvement in the average capability of the men who are in charge of central stations, and even in those isolated cases where young men engaged by the month or year are entrusted with the design and construction of works, the errors which have been committed have been principally such as would lead to an over expenditure of capital rather than to the installation of defective or radically unsuitable plant, and I have sufficient faith in the vitality of electrical supply business to believe that the effect of these errors will, within, say, a couple of years, not influence the result by more than one farthing to one halfpenny per unit. I may be over sanguine, but that is my belief.

Our young engineers are doing well, and if any town council should desire their own electrician to design and superintend the work, I think no one will object, provided they put him in a position of independence of local influence, and pay him the usual fees for his work and responsibility. I am a great believer in adequate pay; put a man in a responsible position and pay him accordingly, and in nine cases out of ten he rises to the occasion, but if he be paid inadequately, he never realises what is expected of him, and consequently fails.

Two or three years ago I could point to several stations suffering acutely from bad management, which are now growing strong and healthy under the care of young men

who, as associates or members, do credit to the Institution of Electrical Engineers, and amongst the many stations which I have seen inaugurated during 1893 and 1894, I cannot to-day name one which is now suffering from careless nursing.

I have addressed the above remarks to you, not as a criticism of Mr. Crompton's address, but as a contribution of my own knowledge of a subject which is of vital importance not only to the industry at large, but to all who have invested money in electricity supply stations, and I am sure that to no one will my testimony on behalf of our young engineers be more welcome than to our new president.

John S. Raworth.

January 14th, 1895.

Muirhead v. Commercial Cable Company.

If, as your correspondent asserts, the rheostat—forming a part of the combination (1880) patent—is utterly useless, it seems curious, and, indeed, a pity, that so many of these instruments should have been "requisitioned" for the purpose, from time to time, since 1880, and should, moreover, have been actually in use on an extensive scale.

Furthermore, the writer of your article does not attempt to give any explanation of the increased speed attained in duplexing cables since the adoption of the 1880 patent, other than the natural inference—*i.e.*, that it is due to the application of this combination.

I should not have supposed it to be necessary at this hour to adjourn either to the laboratory or to the cable station to demonstrate that an exceedingly *low* resistance in circuit with a large capacity, does not introduce retardation where the formerly adopted *high* resistance did. If, however, your correspondent has any doubts on this point, I should be very pleased to try the experiment with him at any cable station, and his historic goose can act as a witness. I should have myself supposed that the experiments of some 30 years ago, on which our K R speed law was based, were sufficiently convincing in this connection.

The Writer of the Article in "Engineering."

Cutting Through the Pole Pieces of Dynamos.

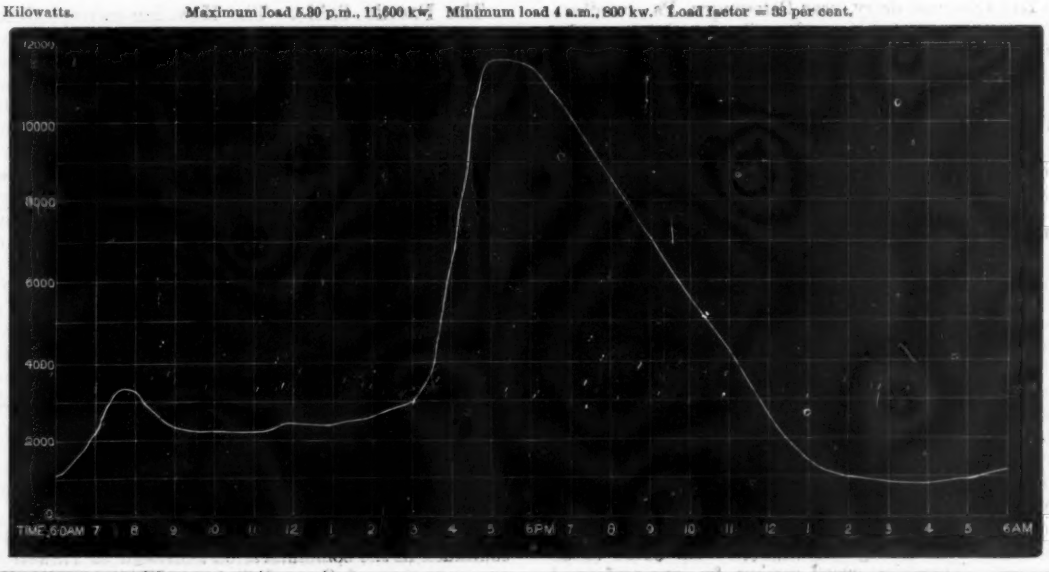
In your description of the new Parker dynamo, the cutting through of the pole pieces is described as a new feature. We built dynamos on this principle more than three years ago. The advantage of lifting the armature clear out of the bearings instead of threading it through the pole pieces is well known to all dynamo manufacturers. We have long since abandoned cutting through the pole pieces in favour of sliding the field magnets apart, which we consider is a better and more simple way of attaining the same ends.

The Coventry Electrical Engineering Co., Limited.
W. H. EAVES, A.I.E.E., *Managing Director.*

[What we intended to indicate as the new feature of the Parker dynamo described in our last issue, was the hinging of the cut pole pieces. We are quite aware that others, besides our esteemed correspondents, tried years ago the cutting through of the pole pieces.—EDS. ELEC. REV.]

CURVE ILLUSTRATING MR. CROMPTON'S PRESIDENTIAL ADDRESS.

LOAD curve showing the combined output of the whole of the London Central Stations during the 24 hours ending 6 a.m. on December 20th, 1894 (from data kindly supplied by the engineers-in-charge).



NOTES.

Electric Light Photography.—In the *British Journal of Photography* we observe that a Mr. Adamson, of Glasgow, has been exhibiting a photographic apparatus using 50 C.P. incandescent lamps, about 40 in number, arranged in a circle inside an umbrella-shaped reflector. The lamps are run up to double or treble their normal power at the moment of exposure. This, as every electrician knows, will not only blacken the lamps at once, but shorten their life at the same time. The arc lamp is now so perfect, its light is so much better than daylight for portraiture work, and the cost of maintenance and for current so small compared with that of the incandescent system, that we fail to see the reason for the adoption of incandescent lamps for such a purpose.

Proposed San Francisco-Honolulu Cable.—Mr. Hatch, Hawaiian Minister for Foreign Affairs, is now on his way from Honolulu to Washington, his object being to push forward the project for laying a telegraph cable from San Francisco to Honolulu.

Artificial Diamonds.—Writing to *Engineering* under date January 5th, Mr. Charles S. Parsons says: "In reference to the summary published in your columns of last week of M. Moissan's paper on diamonds, I have pleasure in inclosing you a copy of a paper reprinted from the *Proceedings* of the Royal Society, June, 1888, from which it will be seen that minute diamonds, both black and transparent, were produced at that time by heating carbon electrically under pressures exceeding 3 tons per square inch."

Medical Electricity.—The Société Française d'Electrotherapie is organising an exhibition of medical electricity, to be held in Paris in April next. We wonder whether belts, and such appliances, will be admitted? We trust the managers of the exhibition will see that bogus apparatus is strictly prohibited.

The Definition of Reactance.—In a communication to the American Institute of Electrical Engineers, Prof. H. J. Ryan says he likes the definition of "reactance" as put forth by Messrs. Steinmetz and Bedell in a recent paper read before that Institute. Had we learned to use alternate currents first, this relation between the constant properties of a circuit, the current and electromotive force, would first have been understood instead of Ohm's law:

$$\text{Impedance} = \frac{E}{I}.$$

Experience would next have taught us that this impedance relation is made up of two fundamental component relations; the one is a power relation, and the other a wattless relation. Because of our early familiarity with direct currents, we learned long ago to write the power relation as:

$$\text{Resistance} = \frac{\text{power } E}{I},$$

and, now, if we accept this definition of "reactance," the second and equally important component of the impedance law will take the same simple form,

$$\text{Reactance} = \frac{\text{reactance } E}{I}.$$

Electric Power on the Farm.—During the past three or four years there has been a considerable amount of talk, especially in the prospectuses of "fake" electric railroads, and in the pages of popular magazines, of supplying electric power to farmers, especially those situated along the line of electric railways. It seems, however, from an article in the *Street Railway Review* (November), that a promising beginning in this direction has already been actually made. The Crystal Hill farm and dairy, near Catasauqua, Pa., handles a large amount of corn fodder and ensilage, and is provided with silos having an average capacity of over 1,000 tons. The expense of preparing the ensilage by horse-power was found to be very great, and this led to the substitution of steam-power. An engineer had nevertheless to be employed, and all the coal used hauled a long distance by team, so that although steam proved to be cheaper than horse-power, the expense was still considerable. In the fall of 1892 an electrical contractor of Catasauqua induced the proprietors of the farm to try electricity. A 220-volt circuit, 2½ miles in length, was extended from the terminus of the lines of the local lighting plant, and a 5 horse-power direct current motor was installed at the farm, which served to operate the churns, cream separator, bottle washer and ventilating fans during hot weather, while the same circuit furnished abundant electric light to all the farm buildings. This experiment, the *Engineering Magazine* states, proved so successful, that the 25-horse-power steam engine was soon afterwards replaced by a 10-horse-power motor of the same type as the first. The motor soon demonstrated its superiority over the steam engine for the particular class of work it was called upon to do. Seventy head of milch cows are fed on ensilage during the year, for which the adoption of the electric motor has reduced the cost of preparing the ensilage from $1.50 to 80 cents per ton. Threshing, wood sawing, &c., are performed by the same power. In the same region the Allentown stock farm of Hon. J. Roth has installed a 15-horse-power direct current motor, which takes current from the trolley line of the Allentown and Lehigh Valley Traction Company by a specially constructed single-wire line 3,300 feet in length. The current is sold by meter, at 8 cents per kilowatt hour. The motor is placed in a building back of the barn, and belted to a main shaft supplied with pulleys for operating various kinds of farm machinery. Threshing, cutting feed, grinding grain, shelling corn, pumping water, sawing wood, &c., are done in this way. A barn, 50 by 208 feet, is also supplied with electric lights. Mr. Roth says that he finds that electricity is not only much cheaper than steam or horse-power, but that it is far more convenient and more safe. He is strongly recommending other large farmers in his vicinity to adopt it.

The Royal Society.—Before this Society, yesterday afternoon, 17th inst., Mr. W. M. Mordey read a paper on "Slow Changes in the Magnetic Permeability of Iron."

The Northern Society of Electrical Engineers.—The following is the result of the ballot for new members and associates, which took place on Monday, January 14th, 1895:—Members—J. G. Calvert, Manchester; S. H. Casson, Manchester; M. Holroyd Smith, London; A. Stahl, Manchester; P. C. Pope, Burnley; A. H. Robinson, Liverpool; Wm. Lawrie, Prescot; G. B. Samuelson, London; F. C. Gibbons, Manchester. Associates—S. Hartford, Manchester; R. Wood, Manchester; A. L. Lind, Manchester.

Quick Work.—The *Scientific American* recently recorded an excellent feat of enterprise upon the part of the Brush Electric Company over the other side:—"About 1 o'clock in the morning of October 13th last a telegram was sent from J. E. Ridall, Pittsburg, agent of the Brush Electric Company, to his company's works at Cleveland, to the effect that the station of the Allegheny County Light Company, of Pittsburg, had been partially consumed by fire, and 12 65-light arc dynamos in the plant damaged to an extent which rendered them useless. This telegram, through some delay, did not reach Superintendent C. W. Phipps, of the Brush Company, at his residence until as late as 2 a.m. Dressing immediately, he hurried to the house of Manager A. D. Dorman, of the order department, and after a hurried consultation, Mr. Phipps and Mr. Dorman quickly agreed upon a plan of action. Before 11 a.m. the 12 65-lighters were ready for shipment, a number of the dynamos having to be partially assembled. At 3.35 p.m. they were at Pittsburg, the run having been made in 4 hours and 35 minutes, better than average passenger time. The total time consumed from the receipt of the telegram by the Brush Company until the machines were delivered at the station was 14 hours."

The Pacific Cable.—The Hawaiian correspondence was transmitted to the United States Congress on Wednesday, 9th inst, with a message from President Cleveland, in which he says: "I submit herewith certain despatches from our Minister in Hawaii, and the accompanying documents. They disclose that Hawaii desires to lease to Great Britain one of the uninhabited islands as a station for a submarine telegraph cable between Canada and Australia, with connection between the island leased and Honolulu. Both Hawaii and the representatives of Great Britain, in the negotiations, concede that the proposed lease cannot be effected without the consent of the United States, owing to our reciprocity treaty with the King. The latter agreed that as long as the treaty remained in force, he would not 'lease, otherwise dispose of, or create a lien upon any port, harbour, or other territory in his dominion, or grant any special privilege or right of use therein to any other Power, State, or Government.' At the request of Hawaii, this subject is laid before Congress for its determination upon the question of so modifying the treaty as to permit of the proposed lease. It will be seen that the correspondence between Hawaii and the British negotiators negatives the existence on the part of Hawaii of any suspicion of British unfriendliness or fear of British aggression. The attention of Congress is directed to the following statement contained in the communication addressed to Hawaii by the representatives of Great Britain:—'We propose to inform the British Government of your inquiry whether they would accept the sovereignty of Neckar Island, or of some other uninhabited island, on condition that no subsidy be required from you. As we have explained, we have not felt at liberty to entertain that question ourselves, as we were definitely instructed not to ask for the sovereignty of any island, but only of a lease simply for the purpose of the cable.' I hope Congress will see fit to grant the request of Hawaii, and that our consent to the proposed lease be promptly accorded. It seems to me that we ought not, by a refusal of this request, to stand in the way of the advantages to be gained by Hawaii through telegraph communication with the rest of the world, especially in view of the fact that our own communication with that country would thereby be so greatly improved, without apparent detriment to any legitimate American interest."

The Institution of Electrical Engineers.—On Thursday, January 24th, a paper on "The Origin and Development of the Telephone Switchboard," will be read by J. E. Kingsbury, associate.

Euston Road Explosion.—The *Daily News* says that having regard to the evidence given at the recent inquiry respecting the Euston Road explosion, the Highways Committee of the County Council propose that plans for street boxes in connection with electric lighting should only be approved on the condition that provision is made for their adequate ventilation.

British Tramways.—A return issued last week by the Board of Trade shows that at the end of June, 1894, there had been authorised for tramway construction in the United Kingdom £17,743,035, of which £14,112,573 had been paid up, £14,388,698 representing the sum expended in building and equipping 975 miles of line. To work this system there were employed 30,528 horses, 564 locomotives, and 4,179 cars, and there were conveyed in the 12 months 616,972,830 passengers, against 598,289,509 in the previous year. The financial results of working for the 12 months and two previous years were:—

	1893-4.	1892-3.	1891-2.
Receipts	£3,615,837	£3,606,095	£3,531,431
Expenses	2,859,056	2,837,446	2,853,356
Net	756,781	768,649	678,075

The rate of working for 1893-4, namely, 79 per cent., was, as in previous years, very high, but the return on the paid-up capital was equal to a little over 5¼ per cent.

An Electric Denture.—Writing to the *British Medical Journal*, Mr. Geo. F. Chutter, A.I.E.E., of Birmingham, says: "A friend recently called on me with the inquiry, 'Could I tell him if he had any electricity in his mouth?' In reply to my look of astonishment, he added: 'I have a most severe pain in my tongue; it is very sore. I have been to my doctor and dentist. I wear artificial teeth. The dentist says my teeth are all right, nothing wrong with them. The doctor says my tongue is all right, and pooh-poohs the whole matter,' and, with a ghastly expression, my friend speaks of cancer, spending his Sundays before the mirror looking for some dreadful sign of this disease on his tongue, and generally driving himself silly. Upon examining his teeth I find two metals are used to fix them to a composition plate. To these metals I attach wires, and put a galvanometer in the circuit; then putting his teeth into his mouth, I ask him to moisten the plate and metals with his saliva, which being done, the galvanometer showed quite a large current from so small a source, quite enough to cause ulceration and severe pain when long continued on so sensitive an organ. Upon covering the metals with an insulating varnish, all pain and inconvenience has ceased, and my friend is 'himself again.' As a layman I thought this might interest your readers."

Snowstorm of January 12th.—The snowstorm of Saturday last did very little damage to the telegraph lines in the South of England, or in Scotland; but in some parts of Ireland the effects were very severely felt. In and around Dublin the storm is said to have been the most severe experienced since 1867. In various districts of the Midlands and North of England some damage occurred. The City of Dublin itself suffered most severely from the storm. About a foot of snow fell, and as it fell it froze to the wires. A hurricane of wind following upon this, broke wires and poles in all directions. Most of the iron poles in the city have been bent, and many broken, from this cause. The fine line of 22 copper wires, carrying the connections for the new cable route *via* Nevin, and other important circuits, was broken down in the city. On the 13th, Dublin's telegraphic communication was confined to a few local offices in the vicinity, and one wire each to Belfast and Glasgow. Considerable trouble was also caused at Belfast, Enniskellen, and other Irish towns. A great quantity of snow fell in the Stafford district, and also in Durham and Northumberland. The damage done, however, was not great. It consisted mostly in single wires breaking and putting others in contact. There was nothing like a general breakdown anywhere on the eastern side of the St. George's Channel.

THE BOARD OF TRADE AND TRANSFORMER CHAMBERS.

THE following correspondence has passed between the Board of Trade and the persons particularly interested in the subject of transformer chambers:—

Sir,—With reference to the hearing which recently took place at this office, of objections raised to the various systems of supply proposed to be adopted by the undertakers under the above-mentioned orders, which involve the use of transforming chambers placed underground in the public streets, I am directed by the Board of Trade to transmit to you the accompanying copy of a letter which has been addressed to the London County Council on the matter.

I am, Sir,
Your obedient servant,
FRANCIS J. S. HOPWOOD.

S. Morse, Esq.,
4, Fenchurch Avenue, E.C.

Sir,—With reference to the hearing which recently took place at this office, of objections raised to the various systems of supply proposed to be adopted by the undertakers under the above-mentioned orders, which involve the use of transforming chambers placed underground in the public streets, I am directed by the Board of Trade to inform you that, as arranged at the hearing, they have consulted their legal adviser, who is of opinion that the expression "regulating or controlling the supply of energy" means or includes the transforming of energy, and accordingly that there is sufficient authority in Section 12 of the County of London (North) Electric Lighting Order, 1892, and in the corresponding sections of the other orders mentioned above, for the construction of such boxes as may be necessary for that purpose, and further, that, so far as the section itself is concerned, there is no limitation with respect to the size of the boxes.

In view of this opinion, and after a careful consideration of the representations made at the hearing, the Board of Trade are not prepared to hold that sufficient reasons have been advanced, either on the ground of public safety or of want of Parliamentary sanction, to justify them in refusing to approve of a system of supply which involves the use of transforming chambers under the public streets.

The Board of Trade, however, consider that the use of the public streets for such a purpose should be as much as possible limited, and that the chambers should be placed where they do not unreasonably interfere with existing underground works of any kind.

In these circumstances, the Board of Trade will be prepared to approve the systems submitted by the undertakers under the above-mentioned orders, with certain alterations, which will be communicated to the Council shortly.

The Board of Trade hope that their decision on the general question will render unnecessary any further action with regard to the appeals which have been lodged by the undertakers under Section 13 of the County of London (North) Electric Lighting Order, 1892, and of the Wandsworth Electric Lighting Order, 1892. Should, however, any difficulty arise in connection with any particular chamber, it would, of course, be open to the London County Council, the local authority, and the undertakers, to avail themselves of the provisions of the sections of the Orders relating to the construction of works.

I am, &c.,
COURTENAY BOYLE.

The Clerk to the London County Council,
Spring Gardens, S.W.

BUSINESS NOTICES, &c.

Crowded Out.—Owing to pressure upon our space this week we have been compelled to hold over for our next issue several important Notes and Business Notices, also some descriptions of new apparatus.

Aberdeen.—As we stated last week, Mr. E. T. Ruthven Murray, who has for some time been in charge of the Aberdeen central station, has been appointed chief electrical engineer at Worcester. An application has been received from Mr. Wakon, superintendent to the Preston Electric Lighting Company, for the post to be vacated by Mr. Murray. We learn that applications for the post are to be invited by advertisement.

The new police offices in Aberdeen are lighted throughout by electricity. There is also a complete telephone installation.

Bath.—The City Council, on Monday morning, unanimously decided (gas company shareholders abstaining from voting) to apply to the Board of Trade for an electric lighting provisional order, and to oppose the application of the City of Bath Electric Lighting and Engineering Company.

Battersea.—In view of the applications which are being made by private companies for permission to lay down mains in the district for supplying the electric light, Battersea Vestry has resolved to enter formal notice of opposition, and has also appointed a special committee to consider and report as to the advisability of the local authorities undertaking the supply on their own account.

Bedford.—The contract for the wiring of the Town and County Club has been given to the local firm of Messrs. Kilpin and

Billson, and the work is being carried out under the supervision of Mr. J. Hardie McLean, who has been appointed their consulting engineer.

Belfast.—The District Lunatic Asylum Governors have ordered inquiries to be made as to the respective costs of lighting the proposed auxiliary asylum by gas and electricity.

Birkenhead.—The Town Council has agreed to the recommendation of the Finance Committee, that Mr. Shoolbred be requested to prepare and submit complete working plans, sections, specifications, and conditions and form of tender in connection with the erection of the central electric lighting station, in order that quantities may be taken out and tenders obtained.

Birmingham.—At the Midland Institute *conversazione* to be held here shortly, the electric light will be used both for lighting and decoration. There are to be a number of electrical exhibits, including the teleautograph. Among the exhibitors are Messrs. Nalder Bros.

Buluwayo.—It is stated that arrangements are being made for the fitting up of a telephone exchange, the erection of an electric lighting installation, and for the construction of water works, at Buluwayo.

Cardiff.—A resolution to appoint a special committee to inquire into the delay in completing the electric lighting of the town has been defeated by 15 votes to 5.

Chelsea.—We are informed that the Chelsea Electricity Supply Company have submitted a tender to the Chelsea Vestry for lighting some of the streets of the parish with electricity. The cost to the vestry of the lamps to be lighted during ordinary lighting hours would be £28 per lamp per annum, with a minimum of 50 lamps, the contract for lighting to be not less than seven years in duration. The lamps and lamp-posts cost from £25 to £30 each, and will be provided by the vestry, the cost of the mains and cables necessary for conveying the supply of electricity to the lamps being borne by the company. The price of £28 will include the maintenance of the lamps in working order. The painting and glazing of the lamp-post and lantern will be done by the vestry. The cost of gas over the area proposed to be treated is £574, while the cost of electricity on these conditions will be £1,400. The matter is to be considered at the next meeting of the vestry.

Cheltenham.—There has been several claims made against the Town Council for damages sustained by passers-by while the council's employés were engaged making excavations. A Mr. Muller claimed £10 for injuries to the knees of his horse, and the council awarded him £5; another gentleman received 15s. for damage done to some boxes of his; but a third unfortunate pedestrian who claimed from the council because he was unlucky enough to tumble into one of their trenches, spoiling his clothes and a thumb at 1.30 a.m., has received nothing, and the council deny any liability in his case.

Dover.—At the last council meeting the town clerk stated that the electric light company had paid £344 4s. to the council for labour and materials supplied during the months of September and October. The surveyor submitted the account against the electric light company for December, £138 1s., and this was ordered to be sent to the company. The surveyor further stated that the cost of work done for the electric light company during the year was £1,322 13s. 9d., including 10 per cent. for supervision. In reply to the chairman, the surveyor said this had all been paid, with the exception of £154, the November account, and the bill for December, which had just been ordered to be sent.

Folkestone.—Mr. W. G. F. Webster has offered to light the Lees with the electric light for a term of years. His letter has been referred to the Lighting Committee.

Hammersmith.—The Vestry, considering the time has arrived when electric lighting should be introduced into the district, has appointed a committee to go into the matter.

Hull.—There was a large assembly at Hull, yesterday, when the ceremony of starting the new engine and dynamo and motor generator was performed at the central station.

Kendal.—The Town Council have resolved to give notice of objection to the granting of a provisional order to the Windermere and District Electricity Supply Company, Limited.

Killarney.—At the Killarney Quarter Sessions at the end of last week, the case of the Killarney Electric Light Company against the Killarney Town Commissioners was opened. The company claimed for two quarters' payments (£19 19s. and £17 10s. respectively) for lighting the town. The case was gone into in detail, and occupied two days in the court, but is not of very great interest outside Killarney. The judge reserved his decision.

Lambeth.—The Vestry have instructed their clerk to report upon the precise position of the parish in regard to the electric lighting order.

Liverpool.—On Monday, the special lighting committee resolved to recommend the City Council to obtain from the Board of Trade a provisional order, authorising them to supply electricity to private consumers all over the city, including the central and residential areas, within which the powers of the Liverpool Electric Supply Company are operative.

Newington.—A lengthy discussion arose at the Vestry meeting the other day regarding electric lighting. It was decided to give notice to the Board of Trade of the intention of the Vestry to oppose the granting of a provisional order to the City Electric Lighting Company.

Norwich.—A new laboratory has been fitted up on the premises of the Norwich Grammar School for the practical teaching of chemistry and physics. In the basement there has been fitted a gas engine and a dynamo, which effect the lighting of the laboratory, and are also used for educational purposes.

Redcliff.—As an experiment, a portion of the nave of St, Mary, Redcliff, was illuminated last Friday night with the electric light. Four bays, two on each side of the nave, were illuminated, there being 30 incandescent lamps, each of 16 C.P.

Sheffield.—Last Monday night there was a temporary failure of the electric light. For nearly three parts of an hour, between half-past six and a quarter past seven, there was no supply, and gas and candles were called into requisition to enable business to be carried on. The new engines and machinery of the Electric Light Company are now ready for use, and it is stated a repetition of the mishap is not likely to occur.

Sunderland.—The electric light may be expected some time during February; £131 is to be expended upon purchasing 26 meters.

Walsall.—Tenders have been accepted for the electric lighting installation, a list of them being published in our "Contracts" column. The Town Clerk has now been empowered to raise £15,000 on account of the loans of £19,000, sanctioned by the Local Government Board, for carrying out the scheme.

Wandsworth.—The vestry has resolved to oppose the commencing of all works in connection with the electric lighting supply to the district until all questions in connection with the proposed system has been settled, and not to sanction the laying of the mains; further, to inform the Board of Trade that the vestry adhere to their objection to the construction of transformer chambers on the public way.

Warminster.—The District Council recently applied to the Local Government Board for sanction to their application to borrow money for extending the electric lighting installation, but as they have not yet received a license for carrying out the work from the Board of Trade, the sanction has been withheld for the present.

Whitehaven.—At the last meeting of the Town Council it was resolved that McGarry's Buildings and Brow Steps be lighted from the harbour circuit and during harbour hours. The surveyor was instructed to prepare an estimate of the cost of the new electric cables required in connection with the lighting of the extended districts at Kells Cottages and Harras Moor, and also for any additional domestic cables in the town which he considered might be required. The engineer was instructed to lay a new electrical cable from James Street *via* Queen Street, Coats Lane, and Roper Street, to the south end of King Street, at an estimated cost of £120. A sub-committee on the lighting of George Street and Lowther Street reported that there was no necessity for extra lighting at present. Alderman Pattinson said the committee thought they would consider the whole lighting of the town later on, and probably there would be something further done before next winter.

Yarmouth.—At the last meeting of the Town Council, it was stated that the first engine and dynamo for private lighting had been received, and would be shortly in operation. The surveyor presented a scheme for lighting St. Andrew's Ward by electricity, the capital expenditure involved being as follows:—Additions to buildings, £500; boiler engines and dynamos, £2,500; crossing rivers, £600; street mains and transformers, £6,400; lamps and posts, £1,000; a total of £11,000. This estimate provides for an installation of 3,000 private lights, yielding a revenue of £1,500 per annum, upon which there would be some profit. Consideration of this scheme has been deferred for six months.

Ballroom Lighting.—On the occasion of a ball at Breckenbrough Hall, near Thirsk, recently, the ballroom was lighted by electricity.

Glass v. The Chelsea Electricity Supply Company, Limited.—In the Chancery Division of the High Court of Justice on Friday the 11th inst., it was arranged before Mr. Justice North that a motion in this action should come before his Lordship on Friday the 25th inst.

Lowestoft Telephones.—The National Telephone Company recently offered to fix telephonic communication between various corporation offices, &c., for £33 17s. 6d. per annum, but the Town Council have not accepted the offer.

New & Mayne.—On Saturday, 5th inst., this firm entertained their staff at dinner at the Masonic Hall, Woking, in honour of the approaching marriage of Mr. Mayne.

Presentation.—Last week the employés of Messrs. Lowdon Bros., Dundee, held their first annual supper in the Café Royal. There were about thirty present. During the evening Mr. P. Nicoll, on behalf of the employés, presented Mr. K. Lowdon with a travelling bag as a token of their goodwill on the occasion of his leaving for Calcutta, where he is to fit up the electric light in two large jute mills.

Quick Work in Electric Heating.—During the recent severe weather the lessees of the Vaudeville Theatre found it necessary to provide some system of warming for the frequenters of their

theatre. After considering several systems of heating by hot water, steam, &c., Mr. Henderson, the manager decided to adopt electric heating, on account of the many advantages of the system. Messrs. Crompton & Co., of Brompton Road, were therefore called upon to supply at once electric heating apparatus suitable for carrying on the work. They received the order at 11 o'clock on Tuesday morning, and by six in the evening the theatre was being warmed electrically. Although no mention has been made of any system of heating having been adopted, many persons remarked on the increased warmth and comfort. The large radiators used were perfectly portable, and, owing to this fact, it was found possible to place them in the stalls during the day and remove them to the sides of the theatre in the evening. Messrs. Crompton & Co., have now received the order for the permanent warming of the theatre, and in a short time it is expected the new system of warming will be complete. The cost is not expected to exceed that of other systems, and this with the advantage of freedom from danger, with perfect regulation, should make the new system of electric heating very popular for theatres.

Siemens Bros. & Co.—Up to the present date this firm have supplied dynamos to 28 stations, aggregating 23,710 H.P., and have also wired 182 ships with an aggregate number of 43,691 lights, averaging 236 lights per ship.

State of Trade during the Year 1894:—

The Electric Construction Company, Limited.—The past year has been a very busy one with the Electric Construction Company, Limited. The reconstruction of the company took place during the latter part of 1893, and during the past year the staff of the company and the business generally has been completely reorganised. It was in April last that Mr. Parker left the company, and Mr. Blackburn was appointed chief engineer. Mr. Garcke who joined the company for a fixed period, retired from the position of managing director at the end of the year. During the period of his connection with the company, the re-construction and re-organisation have been carried out, and we understand the company is now in smooth waters. The business of the company has steadily increased, and we are informed that the orders executed during the past half year have been of an amount equal, if not greater, to that of any previous half year in the company's history. The central station work on hand during the year has included complete electrical equipments for Wolverhampton Corporation, and for the United Parish of St. James and St. John, Clerkenwell; dynamos and accessories for the lighting stations of Halifax, Crystal Palace District, Chelsea, Liverpool, Stafford, Aberdeen, Nottingham, &c.; and a large number of motor generators, both continuous current and alternating current, for various stations, including Brighton Corporation, Oxford, &c., &c. Traction work has included the extensions of the Liverpool Overhead Railway; complete electrical equipment of the Madras Electric Tramways, and electric locomotives for South Africa. In general dynamo, motor and switch work the company has been exceedingly busy, an unprecedented number of machines for private firms having been delivered during the autumn. Several large orders for power transmission, mining and pumping plant have also been executed. The orders at present in hand are sufficient to keep the shops fully employed for several months, and include the equipment for Clerkenwell, alternators and transformers for St. Pancras Vestry, six 65-kilowatt transformers for Birmingham, plant for South Africa, dynamos for the War Office, motor transformers for Manchester and Birmingham, lighting plant for China, &c., in addition to a large number of general orders.

Willans & Robinson.—Some figures received from Messrs. Willans & Robinson show that the year 1894 has not been a very bad one for the electric lighting and kindred industries. The following figures show how rapidly the use of Willans high-speed engines, the greater number of which have been used for the direct driving of dynamos, is extending. The horse-power of the Willans engines ordered during the last four years is as follows:—1891, 11,100; 1892, 14,300; 1893, 18,950; 1894, 26,624; and the total power of engines of this make in use has doubled itself in the last two-and-a-half years. In the summer of 1892 only 51,900 were at work, while at the beginning of 1895 the figures stood at a little over 102,000. The size of the engines has also increased. During the past year the average H.P. of the whole number ordered was 166 H.P., as against 128 H.P. in the previous year. The principal engines ordered included two of 1,400 H.P., each for two electric locomotives on the Heilmann system now being constructed in France, and eight of 700 H.P. each, through the British Thomson-Houston Company for the City of London Electric Lighting Company. These engines, which are to be coupled direct to Thomson-Houston alternators, running at 300 revolutions per minutes, not only form one of the largest electric lighting orders ever given in this country, but are by far the largest high-speed engines that have yet been used for dynamo driving, though several Willans engines of equally heavy size are driving factories. Up to the present, the largest, so far as we know, have been Willans engines of about 350 H.P., and the advance to engines of double the size marks a new departure in the history of electric lighting. The following lists of central stations in Great Britain for which orders have been received for Willans engines, and in which engines have been erected during the year, show how rapidly the electric lighting is being taken up all over the country, and also how much of it is in the hands of municipal authorities.

1. Central station orders for Great Britain only received during 1894:—Westminster Electric Light Company (additions), 1,280 H.P.; City of London Lighting Company (additions), 5,600 H.P.; Kensington and Knightsbridge Company, London (additions), 360 H.P.; Liverpool Electric Light Company (additions), 600 H.P.; Norwich Electric Light Company (additions), 270 H.P.; Birmingham Electric Light Company (additions), 300 H.P.; Chelsea Electric Light Company, London (additions), 655 H.P.; Blackburn Corporation, 560 H.P.; Edinburgh Corporation, 1,750 H.P.; Sunderland Corporation 354 H.P.; Yarmouth Corporation, 420 H.P.; Cheltenham Corporation, 360 H.P.; Brighton Corporation (additions), 600 H.P.; Glasgow Corporation (additions), 720 H.P.; Tunbridge Wells Corporation, 300 H.P.; Aberdeen Corporation (additions), 400 H.P.; Whitehaven Town and Harbour Trust (additions), 120 H.P.

2. Principal places where engines have been erected during 1894:—Nottingham Corporation Electric Light Station, 650 H.P.; Bradford Corporation Electric Light Station (additions), 200 H.P.; Dewsbury Corporation Electric Light Station, 450 H.P.; Bristol Corporation Electric Light Station (additions), 360 H.P.; Hampstead Vestry Electric Light Station, 860 H.P.; St. Pancras Vestry Electric Light Station (additions), 400 H.P.

The horse-power of the Willans engines ordered by or for municipal authorities for electric lighting during 1894 amounts to more than 5,550, of which about 1,850 is for stations where these engines are already in use, while the orders for electric lighting companies amount to 9,000 H.P., all of which represents additions to existing Willans engines. Thus, more than half of the total orders received are for public lighting in Great Britain, the remainder amounting to over 11,650 H.P. are for private and foreign electric lighting installations, electro-chemical, and electric traction work, mill driving, &c.

The following may be noticed:—United Alkali Company, 180 H.P.; Messrs. Albright & Wilson, Oldbury (additions), 750; Army and Navy Stores, London, 300; Liege lighting, Belgium, 390; St. Petersburg lighting, 600; Caen lighting, France (additions), 250; Liège Electric Tramways, 720; Dutch State railways, (additions), 120 H.P.

Among other work erected and started during the year are the following:—Birmingham Grand Hotel, lighting, 180 H.P.; Messrs. Berkenbusch & Co., Brunswick (driving flour mill), 450; Messrs. Gunning & Campbell, Belfast (driving flax mill), 500; Messrs. Albright and Wilson, Oldbury, 300; Rotterdam Electric Light Station, 400; Holborn Restaurant, London (lighting), 400; Biarritz Electric Light Station, 180; Glasgow Post Office, 240; Hove Electric Light Company (additions), 200; Messrs. McKechnie, Widnes, 270; London, Brighton, and South Coast Railway, Newhaven (additions), 150 H.P.

Electro-chemical work for which several orders have been received, including those of Messrs. Albright & Wilson, Oldbury, Messrs. McKechnie, Widnes, and the United Alkali Company, is specially adapted to the Willans engine, which is capable of making the long runs at full load often required. The engines at Messrs. Albright and Wilson's are called upon to run for six weeks at a time without a stop, and we understand that it was the satisfactory performance of the first two engines of 300 H.P. which led to the second order.

The engines for the Liège tramways will form the second installation of this kind for which Messrs. Willans & Robinson have supplied engines. About two years ago, a station of about the same power was fitted up in Hobart, Tasmania, and the plant has been running with perfect regularity ever since. It is stated that Messrs. Willans and Robinson have several important tramway engine orders in view in England as well. The two large mill engines started have proved most successful. They are not the first, two or three of about the same size and many smaller ones being at work, but they represent considerable improvements on what has been already done. Messrs. Gunning & Campbell's engine has recently been tested, and the consumption was proved to be less than 12·8 lbs. of steam per I.H.P. per hour. The steadiness of drive, owing to the high-speed (300 revolutions per minute) and even turning moment, was proved by diagrams taken by a Moscrop speed recorder to be very considerably greater than that of the older slow running engines, being no more than about 0·2 per cent. per revolution of the mean speed. Two Willans engines of 200 H.P. each were exhibited at the Lyons Exhibition where they supplied light to several of the buildings and obtained the grand prix.

During the year orders have also been received for engines to light mines, drive mining stamps, and to drive air compressors, the compressors themselves being Willans engines modified to work as pumps instead of motors. The company have recently bought a site of about 25 acres at Rugby where they intend to start building shops at once to deal with their heavier class of work, and so relieve the factory at Thames Ditton, which has been considerably overtaxed for some time past.

The City of London Electric Lighting Company, Limited.—The directors have issued a special notice giving a list of allowances to consumers and reduction of meter rentals. They have decided to allow discounts to the customers of the company in accordance with the following scale, until otherwise resolved by the board (at 8d. per Board of Trade unit, the Company's standard rate):—

5	per cent.	off a	Bill	amounting to	£100	per	annum.
7½	"	"	"	"	£200	"	"
10	"	"	"	"	£400	"	"
12½	"	"	"	"	£550	"	"
15	"	"	"	"	£700	"	"
17½	"	"	"	"	£850	"	"
20	"	"	"	"	£1,000	"	"

Accounts will be rendered as hitherto at 8d. per Board of Trade unit, and the discount under the above scale will be allowed in the accounts rendered for the last quarter of the year, provided the account for each quarter is paid within one calender month from the last day of such quarter, and no consumer will be entitled to any discount until he has been supplied for a complete year from January 1st to December 31st. A consumer connected to the company's mains at any date between January and December, will not be allowed discount until after the expiry of 12 months dating from the following 31st December after his connection. He will then receive discount, based upon his annual consumption, for the whole time he has been connected. A customer taking current for less than 12 months will

not be entitled to any discount. Each tenancy in a building to be treated as a separate consumer. The rate for current for lighting at night (between the hours of 10 p.m. and 6 a.m.) and for motive, heating, and cooking purposes will remain for the present 4d. per Board of Trade unit, and will not be subject to the above scale of discounts. The board have also authorised the following reduction in the rental of meters: Rent per quarter (from 5s. to) 2s. 6d., up to 50 lamps of 8 candle-power; above 50 lamps, for every additional 50 lamps or part of 50 of 8 candle-power, 2s. 6d. The above alterations will take effect as from January 1st, 1895. We certainly think it is high time the company made reductions more attractive to consumers. We fully believe they would find it well worth their while to reduce the charge per unit.

The Pneumatic Typewriter, Limited.—The Consolidated Telephone Construction and Maintenance Company, Limited, write us as follows:—"As considerable prominence was given to the fact that heads of agreement had been entered into between the above and this company respecting the manufacture of the typewriters, may I beg that you will kindly state that the said heads of agreement have now been agreed to be cancelled."

CONTRACTS OPEN AND CLOSED.

OPEN.

Newport.—Tenders are invited for a complete electric light installation for the Museum and Art Gallery in Dock Street, in accordance with plans and specifications, which may be seen upon application to Messrs. Swash & Bain, architects, Friars Chambers, Newport.

Saint-Die (Vosges, France). — February 1st. The Municipality are inviting tenders for the concession for a central electric light station for the town.

Switzerland.—Tenders are just now being invited by the municipal authorities of Aaran for the construction of a weir on the river Aare in connection with the municipal water-power driven electric lighting station in that town.

CLOSED.

Aberdeen.—The contract for wiring, for electric lighting, the Municipal Buildings, has been given to Messrs. New & Mayne, £200.

Stafford.—At a meeting of the Stafford Town Council on Tuesday last week, the Electric Lighting Committee recommended that the tender of the Electric Storage Syndicate (query Chloride Electric Storage Syndicate) be accepted for the construction of the accumulators at a cost of £822; also that of £524 18s. from the Electric Construction Company. Whether the latter tender is for plant or anything else is not stated. This was agreed to.

Sunderland.—The tender of Messrs. J. H. Holmes and Co. to supply a switchboard for the hospital has been accepted, also that of Mr. D. Taylor for wire for the central electric lighting station.

Walsall.—The following contracts have now been placed by the Town Council in connection with the electric lighting of the town:—Thomas Parker, Limited, electric plant (except mains), £5,061; Callender's Bitumen Telegraph Company, Limited (mains), £3,998. H. Gough, constructing the necessary station, £1,750.

Whitehaven.—Tenders were recently received by the Town Council for the supply of incandescent lamps, in connection with the public lighting for twelve months, from the following:—Edison & Swan United Electric Light Company; David Burns; Wilhelm & Co.; Goossens, Pope & Co.; John Whittle & Son; The Zurich Incandescent Lamp Company; Gabriel & Angenault; and Messrs. Ramsay Bros. The lowest tender being that of Messrs. John Whittle & Sons for both Ediswan and Berend's lamps, has been accepted.

CITY NOTES.

Crompton & Company, Limited.

This company has this week offered for subscription at par 5 per cent. first mortgage registered debentures to the amount of £100,000. They are repayable at par on January 1st, 1920, but the company reserves to itself the option of repaying the bonds, or any portion of them, on or after the first day of April, 1900, on giving six months' previous notice of their intention to do so, at the rate of £105 for each £100 bond, and £52 10s. for each £50 bond; or the company may redeem the bonds earlier by purchase in the market, or at six months' notice, at the price of £110. The present issue is to furnish further capital required to meet the growth of business, and it is proposed out of it to discharge the existing £50,000 of first, and £30,000 of second mortgage debentures, the issues of which amount to £48,810, according to the last balance-sheet published. The assets of the company, pledged by a first charge to secure the above issue, are the whole of the freehold and leasehold property, together with the stock-in-trade, plant, machinery, uncalled capital, and other assets (without taking into account the various letters patent or the goodwill of the business), valued by the company at £242,688. This company has always been one of the foremost in electrical work, and we sincerely hope that the confidence of investors in the future of electricity, and in the business in question, will be shown by the result of the issue.

Anglo-American Telegraph Company, Limited.—At a meeting of the board of directors of the Anglo-American Telegraph Company, Limited, held last Friday, it was resolved, after placing the sum of £12,000 to the credit of the renewal fund, to recommend to the proprietors at the next half-yearly general meeting of the company, to be held on January 25th next, the declaration of the following dividends:—1. A balance dividend of 14s. per cent. upon the ordinary consolidated stock for the year ending December 31st, 1894. 2. A balance dividend of £1 8s. per cent. upon the preferred stock for the year ending December 31st, 1894, both payable on January 26th next, less income tax, to the stockholders registered on the books of the company on the 7th inst. After paying the foregoing dividends there will be a balance of about £485 to be carried forward to the next account. The above dividends, together with those already paid, will amount to £2 2s. per cent. on the ordinary consolidated stock, and £4 4s. per cent. on the preferred stock for the year 1894. The register of transfers will be closed from January 11th to January 25th, both days inclusive.

The City of London Electric Lighting Company, Limited.—The board have published the following revenue return for the quarter ended December 31st, 1894:—Revenue from sale of current for public lighting, quarter ended December 31st, 1894, £3,181 3s. 2d.; corresponding quarter last year, £3,105 4s. 9d.; revenue from sale of current for private lighting, &c., quarter ended December 31st, 1894, £26,052 5s. 3d.; corresponding quarter last year, £13,091 9s. 11d; estimated revenue from other sources, quarter ended December 31st, £404; corresponding quarter last year, £450; total, quarter ended December 31st, 1894, £29,637 8s. 5d.; corresponding quarter last year, £16,646 14s. 8d. Increase, £12,990 13s. 9d. Equivalent of 8 C.P. lamps connected on December 26th, 1894, 135,460; increase during quarter, 21,429; equivalent of 8 C.P. lamps connected on December 26th, 1893, 65,341; increase during corresponding quarter last year, 11,896.

British Volta Electric Glow Lamp Company, Limited.—At an extraordinary general meeting of this company, held at 49, Queen Victoria Street, E.C., on December 29th, 1894, the following extraordinary resolution was duly passed: "That it has been proved to the satisfaction of this meeting that the company cannot by reason of its liabilities continue its business, and that it is advisable to wind up the same, and accordingly that the company be wound up voluntarily." And at the same meeting, Albin Hunt, of Chesham and Great Missenden, was appointed liquidator for the purposes of such winding up.

City and South London Railway Company.—The accounts of this company for the half-year ending December 31st show a balance, after providing for the debenture interest and the full dividend of 5 per cent. on the preference shares, sufficient to allow the payment of a dividend on the consolidated ordinary stock at the rate of 1¼ per cent. per annum, and the carrying forward of a balance of £950. The dividend for the corresponding period of 1893 was at the rate of ⅝ per cent. per annum, the balance carried forward being £1,063.

The New Telephone Company, Limited.—At an extraordinary general meeting of this company held on December 19th, 1894, the subjoined special resolution was passed, and at a subsequent extraordinary general meeting of the company, held on January 3rd, 1895, it was confirmed, viz.: "That the company be wound up voluntarily." And at the same meeting, Albert Anns, of Kenmore, Lennard Road, Beckenham, was appointed liquidator for the purposes of such winding up.

The Direct United States Cable Company, Limited.—The board have resolved upon the payment of an interim dividend of 2s. per share, free of income tax, being at the rate of 2 per cent. per annum, for the quarter ending December 31st, 1894, such dividend to be payable on and after the 26th inst., setting aside £3,000 to reserve fund account, and carrying forward a balance of £1,807 19s. 3d.

Wray Electrical Engineering Company, Limited.—This company, of Thornton Road, Bradford, Yorks., resolved, on Nov. 30th, to wind up voluntarily. This resolution was confirmed on December 17th. The liquidator appointed is Mr. J. T. Dyson, of Huddersfield.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending January 13th, 1895, amounted to £1,001; week ending January 14th, 1894, £951; increase, £50; total receipts for half-year, 1895, £2,005; corresponding period, 1894, £1,941; increase, £64.

The Liverpool Overhead Railway Company. The traffic receipts for the week ending January 13th, 1895, amounted to £866; corresponding week last year, £665.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending January 11th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,924.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation January 9th.	Closing Quotation, January 16th.	Business done during week ended January 16th, 1895. Highest.	Lowest.
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	...	...	...	101 —104 xd	101 —104	...	...
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 12s.	£2 15s.	£2 11s.	39½ — 40½	41½ — 42½	40⅜	40
2,993,560£	Do. do. 6 % Pref.	Stock	£5 5s.	£5 10s	£5 2s.	73⅛ — 74½	77⅛ — 78½	78½	73½
2,993,560£	Do. do. Defd.	Stock	...	...	...	6½ — 7	6⅞ — 7¼	6⅞	...
130,000	Brazilian Submarine Teleg., Ltd.	10	8 % §	6½ % §	6½ % §	10¾ — 11¼xd	11¼ — 11⅜	11 1/16	10⅝
75,000£	Do. do. 5 %, repayable June 1906	100	...	...	...	109 —113 xd	109 —113	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	... §	10%‖ §	... §	2 — 3	2 — 3	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	140 —150 xd	140 —150	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	3¼ % §	2 % §	2 % §	1/16 — 3/16	1/16 — 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12½ — 13¼	13 — 14	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	19 — 20	19½ — 20½	19 1/16	...
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4½ %	4 %	4 %	4 — 4½	4 — 4½	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	10 %	9½ — 10	9½ — 10	...	...
30,000£	Do. do. 4½ % Debs of £50, Nos. 1 to 1,600	...	...	...	...	103—106%xd	103 —106%	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½ % §	3½ % §	2⅝ % §	8¼ — 9	8½ — 9 xd	8⅝	...
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½ % §	6½ % §	6½ % §	16⅛ — 16⅜	16⅛ — 16⅜xd	16⅜	16¼
70,000	Do. 6 % Pref.	10	6 % §	6 % §	6 % §	17 — 17½	17 — 17½xd	17 1/16	...
102,100£	Do. 5 % Debs., repay. August, 1899	100	...	...	...	106 —110	106 —110	...	...
1,297,837£	Do. 4 % Mort. Deb.	Stock	...	...	...	121 —124	121 —124	...	...
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	16¼ — 16½	16⅜ — 16⅝xd	16⅝	16¼
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	...	...	...	102 —106 xd	102 —106	105	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	...	...	...	103 —106 xd	103 —106	103½	...
320,000£	Do. 4 % Deb. Stock	Stock	...	...	...	121 —124	122 —125	124	121¾
95,100£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	...	...	...	102 —106 xd	102 —106	...	...
129,100£	Do. do. do. to bearer, 2,344 to 5,500	...	...	...	...	103 —106 xd	103 —106	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	...	...	...	106 —109	106 —109	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	...	...	...	111 —114%	111 —114%	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	5⅛ % §	4⅞ % §	4⅝ % §	8⅞ — 9⅛	8⅞ — 9⅛xd	9⅛	8 1/16
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	6 % §	16½ — 16¾	16½ — 16⅝xd	16⅝	16½
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅝ % §	8⅝ % §	8⅝ % §	21½ — 22¼xd	21½ — 22¼	21⅞	...
190,000£	Do. do. do. 5 % Debs.	100	...	...	...	105 —108	105 —108	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	48 — 50	48 — 50	49⅝	49½
37,548	London Platino-Brazilian Teleg., Ltd.	10	...	...	...	5 — 7	5 — 7	...	...
100,000£	Do. do. 6 % Debs.	100	...	...	...	102 —106	103 —107	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	¼ — ⅜	¼ — ⅜	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	...	...	...	1½ — 2½	1¼ — 2½	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	6 % §	5 % §	5 % §	5¼ — 5½	5½ — 5½	5 7/16	5 7/16
15,000	Do. 6 % Cum. 1st Pref.	10	...	...	...	15 — 17	15 — 17	15½	...
15,000	Do. 6 % Cum. 2nd Pref.	10	...	...	...	15 — 16	15 — 16	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	...	...	...	5⅞ — 6⅛	5⅞ — 6⅛	6	...
1,100,000£	Do. 3½ % Deb. Stock Red.	...	...	...	...	103 —105	103 — 105	104½	103¼
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... — ...	... — ...	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	...	½ — ⅝	½ — ⅝	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	...	...	...	104 —107 xd	104 —107	...	...
11,839	Reuter's Ltd.	8	5 %	5 %	0 %	2 — 4	2 — 4	3½	...
3,381	Submarine Cables Trust	Cert.	...	...	...	110 —115	114 —119	...	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1 — 2	1 — 2	...	...
146,733£	Do. do. 5 % Debs.	Stock	...	...	...	86 — 91 xd	86 — 91	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	4 %	..	0 %	3 — 5	3 — 5	...	...
238,300£	Do. do. do. 5 % Debs.	100	...	...	...	101 —104	101 —104	...	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	1½ — 2½	1½ — 2½	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	...	...	...	96 —101 xd	97 —102	...	...
64,245	Western and Brazilian Teleg., Ltd.	15	4 %	2½%	2½%	11 — 11½	11 — 11½	11¼	10¾
33,129	Do. do. do. 5 % Cum. Pref. ...	7½	...	...	...	6¼ — 6¾	6¼ — 6¾	6⅝	6⅜
33,129	Do. do. do. 5 % Def.	7½	3 %	...	...	4¾ — 5¼	5 — 5¼	5¼	4¾
171,900£	Do. do. do. 6 % Debs. "A," 1910 ...	100	...	...	...	101 —105	102 —106	...	...
214,800£	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	...	...	...	101 —105	102 —106	...	...
88,321	West India and Panama Teleg., Ltd.	10	¼%	¼%	⅜%	1 — 1½	1 — 1½	...	...
34,563	Do. do. do. 6 % 1st Pref. ...	10	...	...	...	10¾ — 11½	10⅞ — 11¼	10⅞	10
4,669	Do. do. do. 6 % 2nd Pref. ...	10	...	...	...	9 — 10	9 — 10	...	...
80,000£	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	...	...	...	107 —110 xd	108 —111	108¾	...
$1,211,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	...	...	...	115 —120	115 —120	...	...
166,900£	Do. do. 6 % Ster. Bonds.	100	...	...	...	102 —104	102 —104	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	...	5 %	4½%	4½ — 5½	4½ — 5½	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	...	...	14 — 15	14 — 15	15½	14½
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	...	6 %	6 %	15 — 15½	15 — 15½	15½	15½
100,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	...	...	...	130 —133 xd	130 —133	133	131½
50,000	†Liverpool Electric Supply, all paid	5	4½%	5 %	5 %	7 5/16 — 7 7/16	7 — 7½	7 1/16	...
49,900	•Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	1 %	2 %	2½%	9¾ — 10¼	9¾ — 10¼	10 3/16	10
100,000£	Do. 5% Deb., bonds of £10, £20, £40 ...	...	...	...	...	... — ...	... — ...	...	...
150,000£	Do. 4½% first mortgage debenture stock	...	...	...	...	116 —119 xd	116 —119	116½	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	...	7¼ — 7⅝	7 — 7½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	8½%	7½%	4½%	7⅝ — 8¼	8 — 8½	8½	8⅛
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8¾ — 9¼	8¾ — 9¼	...	...
59,900	•Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	...	3½%	4 %	7¼ — 7⅝	7¼ — 7⅝	7⅞	7⅞

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, Jan. 9th.	Closing Quotation, Jan. 16th.	Business done during week ended Jan. 16th, 1895. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	...	6 % §	6 % §	2⅝ — 2⅞	2⅝ — 2⅞	2 13/16	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	...	6 % §	6 % §	2¼ — 2½	2⅜ — 2⅝	2½	...
125,000*l*	Do. do. 4½ % Deb.	Stock	...	...	...	111 —114	111 —114	...	...
630,000*l*	City and South London Railway	Stock	...	8/8%	8/8%	43 — 45	44 — 46	45½	44½
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	7 % §	7 % §	7 % §	3 — 3½	3 — 3½	3⅝	...
50,000*l*	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	...	...	...	97 —102	97 —102	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	...	...	...	¼ — ½	¼ — ½	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	...	...	...	1½ — 2	1½ — 2	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd., 1 to 66,750 ...	2	*nil*	*nil*	*nil*	1/16 — 3/16	1/16 — 3/16	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil* ¶	*nil*	*nil*	1¼ — 1½	1¼ — 1⅝	1 7/16	1 5/16
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	*nil*	1⅛ — 1⅜	1 1/16 — 1⅛	1 1/16	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	*nil* §	½ — 1½	½ — 1½	...	...
9,600*l*	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	...	...	6½ — 7½	6½ — 7½	...	...
6,837	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	5 %	8½ — 9½	9 — 10	9½	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	12½%	25½ — 26½	25½ — 26½	26½	26¼
200,000*l*	Do. do. do. 4½ % Deb., 1896	100	...	...	...	102 —104	102 —104	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	...	1 %	8⅞ — 9	8⅞ — 9	...	...
6,295	† Do. do. Pref., £8 paid	10	...	...	...	13 — 13¼	13 — 13¼	...	...
	Swan United Electric Light, Ltd.	...	11 % §	10 % §	7½%§	... — ...	... — ...	...	...
37,250	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	20 %	41 — 43	41 — 43	43	41½
150,000*l*	Do. do. do. 5 % Bonds, red. 1894	100	...	...	...	104 —107 xd	104 —107	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000, £2 paid ...	10	...	...	...	2¼ — 2½xd	2⅜ — 2⅝	2½	2 7/16

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—8%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5¼—5⅜.
Electric Construction Corporation, 6 % Debentures, 93—97.
Electric and General Investment, shares of £5 (£1 paid), 1¾—2¼.
House-to-House Company (£5 paid), 2¼—2½.
Do. do. 7 % Preference, of £5, 6½—7.
Do. do. 6 % Debentures of £100, 105—107.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 7—7¼; 1st Preference Cumulative 6 %, £5 (fully paid), 7—7⅛.
Liverpool Electric Supply, £5 (fully paid), 6⅞—7.
London Electric Supply Corporation, £5 Ordinary, ⅛—¼.
Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 99—101.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares (£4 10s. paid), 4⅛—4⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

ELECTRIC DISCHARGE THROUGH GASES.*

By Prof. J. J. THOMSON, M.A., Sc.D., F.R.S.

One of the most important and interesting branches of physical science is that which deals with the connection between electrical and chemical effects.

The investigations on electrolysis made within these walls by Davy and Faraday proved that the important class of electrical phenomena associated with the passage of electricity through liquids are connected in the closest way with chemical action. They proved that no electricity will pass through most liquids unless chemical action occurs, and that for each unit of electricity which passes through the liquid there is a definite amount of chemical decomposition.

This case, though it is one where the laws are most accurately known, is but one among many electrical phenomena which are inseparable from chemical action.

So many instances of this kind have been discovered, that we may, perhaps, venture to hope that we are not far from the time when it will be universally recognised that many of the most fundamental questions in chemistry and electricity are but different aspects of one and the same phenomenon.

Anything which throws light on the connection between electricity and matter, interesting as it is on its own account, acquires additional interest when regarded as elucidating the connection between chemical and electrical effects, and no phenomena seem more suitable for this purpose than those which are the subject of the discourse this evening—the discharge of electricity through gases. For in gases we have matter in the state in which its properties have been most carefully studied, while the investigation of the electrical effects is facilitated by the visibility of the discharge, affording us ocular, and not merely circumstantial, evidence of what is taking place.

The points to which I wish to refer particularly this evening are, firstly, some phenomena connected with the passage of electricity from the gas to the electrode, or from the electrode to the gas; and secondly, some of the properties of the discharge when its course lies entirely in the gas.

By taking a long discharge tube, say, one 50 feet long, and observing the luminous discharge through a rotating mirror, we can trace the course of the luminosity due to a single discharge, say, one due to once breaking the primary circuit of an induction coil; if we do so we find that the luminosity follows the direction of the positive current through the tube. That is, the luminosity begins at the positive electrode, it then rushes down the tube with enormous velocity, but when it gets to the negative electrode, it receives a check; it does not disappear at once in that electrode like a rabbit going down a hole, but lingers around the electrode some time before entering it. In consequence of this delay in the positive discharge in getting out of the gas, there is an accumulation of positive electricity in the neighbourhood of the negative electrode until the potential fall at this electrode increases to about 200 or 300 volts.

The positive electricity which accompanies the discharge thus finds considerable difficulty in getting from the gas to the metal, though, as I hope to show you later on, as long as it keeps in the gas, it meets

Fig. 1.

with what we may, in consideration of the views sometimes enunciated on this subject, call a ridiculously small amount of resistance, its real difficulty is to get out of the gas.

Though this effect has long been known, it is so important that I

* Paper read before the Royal Institution of Great Britain on Friday, April 13th, 1894.

will venture to show one or two experiments which illustrate it. The arrangement of the first experiment is shown on the screen, the apparatus consists of a main discharge tube, across which is fastened a diaphragm made of excessively thin platinum leaf; there is a side passage from the tube, leading from one side of the diaphragm to the other, this is connected to a barometer tube, and by raising the cistern containing the mercury I can stop up the passage by a pellet of mercury. We will first observe the discharge when the side passage is open; you see that the discharge, instead of passing across the thin piece of platinum leaf, takes the very much longer route round the side tube, so as to avoid crossing the metal. We will now raise the mercury cistern and close the side tube by a pellet of mercury; the discharge now has no alternative but to cross the metal at some part of its course, and you see that the main portion of the discharge goes back into the main tube.

In the second experiment the metal diaphragm is replaced by a very thin plate of mica; when the side passage is opened the discharge goes round, but when this is closed by a pellet of mercury, the discharge prefers to go across the mica than through the mercury.

A second experiment, which shows the same thing, is the following: Two long electrodes are fused into a bulb, so that the tip of an electrode is a considerable distance from the place where it passes through the glass. We will now send an alternating discharge through the tube, and you will see, I think, that the discharge, instead of going

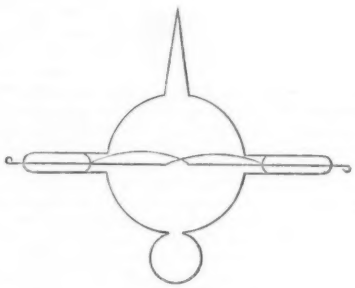


Fig. 2.

straight across the short distance between the ends of the electrodes, goes from the tip of one electrode to the place where the other passes through the glass, thus staying as long as possible in the gas before passing into the metal. The appearance of the discharge shows that the positive electrode is at the end of the wire, the negative at the junction of the wire with the glass.

Another interesting example of the difficulty the discharge experiences in passing from gas to metal is the discovery made by Profs. Liveing and Dewar, that when the discharge passes through a gas containing a large quantity of metallic dust, the light from the discharge, when examined in the spectroscope, does not show any of the lines of the metal.

The difficulty which the positive electricity finds in passing from the gas to the electrode depends a great deal upon the nature of the gas, as well as upon that of the electrode; it is influenced by the position of the gas and the electrode relatively to one another in the electro-chemical series.

I have lately made a series of experiments on this point in the following way. An alternating discharge from a high tension transformer was made to pass between two electrodes fused into a bulb, which could be filled with the gases under examination. Another electrode connected to an electrometer, passed into the bulb, and was arranged so that it could be moved about from one part of it to the other. When the electrodes were metal, and the bulb was filled with the electro-negative gas oxygen, the electrode received a positive charge in whatever part of the bulb it was situated; if now the bulb was filled with hydrogen at atmospheric pressure, then in the regions remote from the arc the electrode received a positive charge, but in the immediate neighbourhood of the arc itself it received a negative charge. When the pressure was reduced, the region in which the charge was negative contracted, and finally at pressures about one-third of an atmosphere seemed to disappear, and the electrode got a slight positive charge in whatever position it was placed. If now, instead of using metallic electrodes we use well oxidised copper ones, and repeat the experiment in hydrogen, working at a pressure when there was only positive electricity, when the electrodes were bright and polished, we find that with the oxidised electrodes every particle of positive electricity is taken out of the tube, and a negative charge is left. This negative charge remains until the copper oxide is completely reduced; when this occurs the negative charge disappears, and is replaced by positive. Thus, under the same conditions as to the nature of the gas and the pressure, the bright copper electrodes leave a positive charge in the gas, while the oxidised ones leave a negative charge.

The most probable explanation of these results seems to me to be the view that the communication of electricity from gas to the electrode, or from the electrode to gas, is facilitated by the temporary formation of something of the nature of a chemical compound between the gas and the metal. In all such compounds the metal is the electro-positive element, and has the positive charge, the gas being the electro-negative, and carrying the negative charge. Now consider the case when the negative charge is on the gas, and the positive charge on the metal; then the gas and metal have got the charges proper to them in any compound they may form, and are thus in a fit state to combine, or, according to this view, allow the negative electricity to pass from the gas to the copper. But now, suppose the gas was positively electrified, the gas and the metal have now opposite charges to those proper to them in a compound, and before the union of gas and metal in this state could result in anything but a most unstable compound, an additional process must be gone through, *i.e.*, the charges on the gas and metal must be interchanged. Thus the conditions for the combination of the gas and metal are more complex when the gas is positively electrified than when it is negatively electrified, and thus, on the view that the communication of electricity between the gas and the metal involves a sort of chemical combination, we see that the negative electricity will escape more easily from the gas to the metal than the positive. Now consider the case when the gas was hydrogen, the electrodes oxidised copper; the hydrogen combines now not with the metal, but with the oxygen, forming water, in which hydrogen is the electro-positive element; thus, in this case, it is the positively-charged hydrogen which is in the state best fitted for pairing. The consequence is, the positive charge would be most readily removed from the gas and the negative left—exactly the opposite to that which occurred when the electrodes were bright. This reversal, as I stated before, is verified by experiment.

I have hitherto only spoken of the phenomena which accompany the passage of electricity from the electrode to the gas, or from the gas to the electrode.

I shall now pass on to consider the properties of the discharge when it is entirely confined to the gas.

We may produce a discharge which, during the whole of its course, shall be confined to the gas in the way represented in the diagram.

The two poles of a Wimshurst machine are connected to the insides of two jars, A and B, while the outsides of these jars are connected

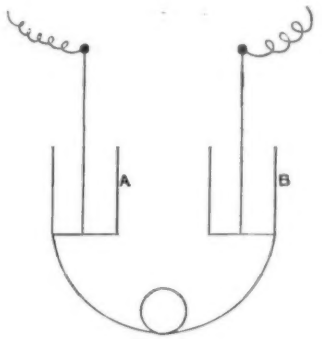


Fig. 3.

together by a metal wire wound so as to form a coil. The electricity from the Wimshurst machine charges up the jars, the difference of potential between the poles increases until a spark passes. The passage of the spark puts the insides of the two jars in connection, and the jars are discharged. The discharge of the jar, as was proved from the theory of electro-magnet action by Lord Kelvin more than 40 years ago, and shortly afterwards confirmed by the experiments of Feddersen, is an oscillatory one, producing currents surging backwards and forwards through the wires with extraordinary rapidity. The subject of these oscillatory currents is one which in this year is tinged with melancholy. The year had hardly commenced when we lost Hertz, whose splendid work on these electrical oscillations is known to you all. The managers of this Institution have marked their sense of the importance of this work by devoting a special lecture this session to this work alone, and they have entrusted that lecture to a most distinguished worker in the same field as Hertz. It would, therefore, be presumptuous on my part to refer in any detail to Hertz's work, but no physicist, and, least of all, one who is a member of Maxwell's University, could pass over in silence the death of Hertz.

When Herts began his magnificent experiments on electric oscillations, there were many theories of electrical action. When he had finished them there was only one, Clerk Maxwell's.

Hertz's work was done with very much quicker vibrations than those produced by the apparatus now on the screen; this, however, gives rise to currents through the coil changing their direction some million times a second. If we place in the coil an exhausted bulb, the bulb in reality will be the secondary of an induction coil, and will be exposed to electromotive forces tending to produce circular currents parallel to the plane of the coil.

I will now place a bulb inside this coil, and you see that a circular ring discharge passes through it, and this discharge passes entirely in the gas.

The gas in the bulb now in the coil is the vapour of silicon tetrachloride; it happens to be the bulb which gives a brighter ring than any others I possess.

If this ring discharge passes through air at different pressures, the colour of the discharge changes very considerably. The first bulb I put in was at fairly high pressure, about $\frac{1}{10}$th of a millimetre or so. I will now put in another at a lower pressure, and then one at a still lower pressure. Mr. Newall, who has been working at the spectra of these discharges, finds that at the pressure in the first bulb the spectrum is due to nitrogen; at the second stage it is due to mercury vapour; the bulb was pumped by a mercury pump, so that there is in the bulb a certain quantity of mercury vapour.

The apple-green colour in the more highly exhausted bulb is due to some compound of sulphur, which has got into the bulb from the

sulphuric acid used to dry the gas. Mr. Newall finds that if the ordinary discharge from a coil between electrodes is taken in such a bulb, there is no trace of this sulphur spectrum. He has also found that when the bulb is at a pressure intermediate between what I may call the mercury and the sulphur stage, when the mercury and sulphur lines are both visible, these sets of lines come from different layers, the sulphur lines coming from a layer nearer the surface than the other.

If we take the discharge through a bulb containing oxygen, you see that the ring discharge is succeeded by a bright glow; at first the colour is somewhat opaque, but gradually gets more transparent and changes colour. This gives a continuous spectrum crossed by a few bright lines. If we take the discharge through cyanogen, you see that the glow is even more persistent than the oxygen, though it is not so bright; all the gases which show this glow belong to the class of substances which polymerise—that is, whose molecules can combine with each other. I imagine that what takes place in bulbs filled with these substances is that the discharge produces a polymeric modification, and that this gradually returns to its original state, and while doing so gives out a phosphorescent light. It is in accordance with this that at a high temperature where ozone cannot exist a discharge through an oxygen bulb does not show any glow.

I said at the beginning of this discourse that gases were exceedingly good conductors of electricity. I will now endeavour to show an experiment which proves that statement. The apparatus which I shall use for this purpose is a slight modification of the one I have used for producing the ring discharge; the only difference is that in the wire connecting the two coatings of the jars there are two loops instead of one. In one of these loops an exhausted bulb is placed to serve as a kind of galvanometer; the brightness of the discharge is an indication of the strength of the current flowing round the coil. If I place a second conductor in the other loop, currents will be started in it, and part of the energy of the discharge will be absorbed; this will leave less energy available for the bulb in the first, so that the discharge in this bulb will be dimmer. The effect produced on the discharge will depend upon the conductivity of the substance placed in the second loop.

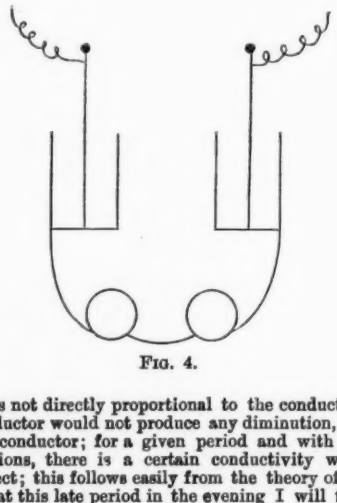


FIG. 4.

The effect is not directly proportional to the conductivity, in fact, a perfect conductor would not produce any diminution, nor would an absolute non-conductor; for a given period and with apparatus of given dimensions, there is a certain conductivity which gives a maximum effect; this follows easily from the theory of induction of currents, but at this late period in the evening I will take a shorter course and prove it by an experiment.

I put a piece of brass in this loop, and you see it produces but a small effect upon the brightness of the discharge. Instead of brass, I now insert a plumbago crucible, which, though a conductor, is not nearly so good a one as the brass, and you see the discharge in the indicating bulb is completely stopped.

I will now place in the second loop an exhausted bulb; you see it produces a decided diminution in the intensity of the discharge in the galvanometer bulb. I now replace the bulb by another of the same size, containing dilute sulphuric acid; you see it does not produce nearly so large an effect as the exhausted bulb: this might be due, as we have seen, to the sulphuric acid being either too good or too bad a conductor. I can show that it is the latter by putting a bulb in filled with a stronger solution, which has a higher conductivity than the weak solution; if the smallness of the effect produced by the weak acid were due to its being a better conductor than the gas, then increasing the conductivity would still further diminish the effect of the acid; you see, on the contrary, that the strong acid produces a distinctly greater effect than the weak, hence the rarefied gas in the bulb is a better conductor even than the strong electrolyte. Let us consider for a moment the molecular conductivities of the two substances, the rarefied gas and the electrolyte. The pressure of the gas is about $\frac{1}{100}$th of a millimetre, while in the electrolyte there are sufficient molecules of the acid to produce, if they were in the gaseous state, a pressure of more than 100 atmospheres; thus the conductivity of the gas estimated per molecule is about 10,000,000 times that of the acid; this is greater than the molecular conductivity of even the best conducting metals.

If the pressure of the gas is diminished below a certain point, the conductivity begins to diminish. I have here an experiment which I hope will show this. The apparatus (fig. 5) consists of two bulbs, one outside the other; the inner bulb contains air at a low pressure, while the space between the two bulbs is a very high vacuum containing practically nothing but a little mercury and its vapour. The amount of mercury vapour in this space is, at the temperature of the room, exceedingly small, but as the apparatus is heated the vapour pressure increases, and we are thus able to produce a fairly wide range of pressure in the space between the bulbs. The outer sphere is surrounded by the coil connecting the outer coatings of the two Leyden jars. When the space between the bulbs is a conductor,

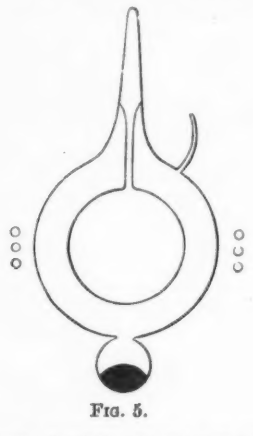


FIG. 5.

the alternating currents circulating in the coil will induce in this conductor currents whose inductive effect is opposite to that of the currents in the coil; and in this case this layer will screen off from the inner bulb the electromotive force due to the alternating currents in the coil. If, on the other hand, the space between the bulbs is a non-conductor, the inner bulb will be exposed to the full effect of these forces. We now try the experiment: you observe that when the mercury is cold, and consequently the pressure in the space between the bulbs very low, a bright discharge passes through the inner bulb, while the space between the bulbs remains quite dark; when we heat the mercury so as to increase the pressure of its vapour, a bright discharge passes through the outer layer, while the inner bulb is quite dark; the outer layer is now a conductor, and by its action screens off from the inner bulb the induction of the coil.

The last experiment I have to show is one on the effect produced by a magnetic field on the discharge. When the discharge has to flow across the lines of magnetic force, the pressure of the magnetic field retards the discharge; when, however, the discharge flows along the lines of magnetic force, the discharge is helped by the magnetic field. This is shown in the following experiment. A is a bulb, B a square tube, one side of which is placed between the poles of an electro-

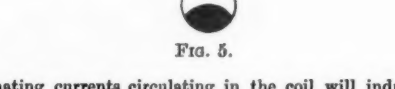


FIG. 6.

magnet; the coil, C, which connects the outside coatings of the jars, can be adjusted so that when the magnet is "off," the discharge passes through the bulb, but not round the square tube; when, however, the magnet is "on," the discharge passes in the square tube, but not in the bulb. In the square tube the discharge passes along the lines of magnetic force, and is helped; in the bulb it passes across them and is retarded.

INQUIRY BY THE BOARD OF TRADE INTO THE ST. PANCRAS EXPLOSION.

ON Thursday, the 10th inst., Major Cardew, R.E., conducted an inquiry into the circumstances attending the explosion of street boxes in Endsleigh Gardens, St. Pancras, on December 29th last. The inquiry was held at the St. Pancras Vestry Hall, and there were also present Prof. Henry Robinson, consulting engineer to the St. Pancras Vestry, who examined the witnesses on behalf of the vestry; Mr. Bassett Hopkins and Mr. Gunyon, representing the London County Council, and Mr. Foulger the Gas Light and Coke Company.

P.C. Diprose, 436 D, stated that he was at the corner of Gower Place and Endsleigh Gardens at midnight, on the 29th ult., when he heard the report of an explosion in the direction of the Euston Road, and turning, he saw a manhole cover being blown into the air to a height of 20 feet. Dense smoke issued, but he saw no flame. Almost immediately a second explosion occurred at the corner of Euston Road and Endsleigh Gardens, 20 yards further on, and the manhole cover there was blown 8 feet away. The pavement was raised for a distance of 40 yards. He took steps to inform the electric light people and the gas company. Three quarters of an hour afterwards two men, named David Petrie and Charles Govier, came to him and complained of having been injured by the explosion. They said they had been attended to at University College Hospital. They appeared to be lame, and covered with mud. There was a smell of gas where the explosion occurred; in his opinion, of coal gas.

Charles Govier, a farrier, of Drummond Street, said he was bidding his friend Petrie good night at the corner of Endsleigh Gardens, when he saw a flash, and was at the same moment hurled into the air. He fell on his back, and as he was trying to rise the ground seemed to heave, and he was thrown into the gutter. When he got up he found Petrie clinging to the railings a short distance away. They both went to the hospital where their injuries were treated.

Mr. A. E. Pycraft, chief clerk to the electricity department of the Vestry, stated that he ascertained next day at the hospital that Govier had a bruised side and Petrie a sprained ankle, both being said to be mild cases.

Mr. J. T. Baron, M.I.E.E., chief engineer and manager of the St. Pancras installation, said it was the business of Mr. Thomas, the outdoor inspector, to see that the manholes were systematically inspected, and to report to him. Each manhole would be inspected every fourth or sixth day. The two at which the explosion occurred were inspected on the day previous to the explosion. Both had been constantly reported as dry, with an occasional smell of gas. Inspection was more frequent when there was a suspicion of gas being present. All culverts and manholes were drained and trapped from the sewers. The last occasion when gas was reported from these manholes was December 13th. The gas company was informed of the fact, but sent no acknowledgment; they, however, sent men to the spot to open the road. Witness was called to the scene of the explosion by the police; he found the manholes blown up, and the roadway lifted up two or three inches for a length of 30 yards. He distinctly smelt gas at one of the manholes. The two manholes, which were 10 yards apart, were connected by an 8-inch cast-iron pipe, carrying three strips of bare copper fastened on insulators. He could find no signs of electrolysis on these copper strips, which were, so far as he could see, in perfect order; the insulators, however, had been displaced. There was no interruption of the supply, and the two 300-ampère fuses in the manholes were not affected. Next day (Sunday), going round with the gas company's inspector, he found a slight incrustation on the negative side of one of the insulators in one of the manholes. Such incrustations were frequently found, but only in the manholes; they were instantly removed, and steps were now being taken to prevent their formation.

Replying to Major Cardew, who said the statement as to cast-iron pipes was a revelation, Witness said there were very few such pipes, which were used where roads or pathways had to be crossed, and where there were other pipes, gas, water, telegraph, &c., to be crossed. The pipes terminated in the manholes at each side.

Major Cardew suggested that the road should be opened in order to see if the cast-iron pipe had been damaged, and it was agreed that this should be done.

Witness continued to state that the suggestions made by Major Cardew, after the inquiry into the explosion in Endsleigh Gardens a year ago, had received their attention, and had been carried out as far as possible. There had been more frequent inspection, ventilating up-cast pipes had been put in in eleven places, and wooden shields had been placed under the iron manhole covers in a number of cases, but it was found that these got wet from condensation, and swelled, and they had been obliged to remove several of them. It had not been found practicable to substitute two or more small chambers for the larger ones. There had been about half a dozen explosions altogether since the works were first started. The insulation of the negative mains from earth was still low, and they had constantly tried to increase it by cleaning the insulators and removing all dampness.

By Mr. Bassett Hopkins: The cast-iron pipes were used in two sizes: those used to carry bare conductors were in all cases 8 inches in diameter, and those carrying cables 3 inches. These pipes were in some instances 18 inches below the surface of the road. They tested customer's work for insulation when the connections were first made, but not afterwards, unless there was some fault. Witness thought coal gas was present in the manholes, and he could not deny that a spark might have occurred and caused the explosion.

By Mr. Foulger: Four men were constantly employed by the department in searching for gas and water. Leak detectors were not used; they depended entirely upon the sense of smell for gas. He did not think the leak detectors worked satisfactorily. The mains were drawn fairly tight; they certainly were not laid loosely on the insulators so that they might easily come into contact. He had known, however, of the mains touching; once, in August, 1893. they did so in several places simultaneously. There was a big fire in Camden Town, three-quarters of a mile away, at the time.

Mr. Foulger: If there were moisture in the culvert, would it not be possible for hydrogen gas to be formed by decomposition?

Witness: There is never sufficient moisture on the insulators to cause an explosion. Continuing, witness said he thought a mixture of 10½ per cent. of gas with air would form an explosive mixture. He had tested for gas at the manholes since the explosion, and had smelt coal gas. He knew it was possible to smell gas from the main when there was no escape. He would not say that if the contemplated alterations had been made the explosions would not have occurred. He had heard that the gas company's officials had been testing for gas since the occurrence, and that they had failed to detect any traces of it.

Mr. W. J. Thomas, outdoor inspector of works to the Electricity Department, said he had charge, under Mr. Baron, of all the mains and connections of the system. The manholes were inspected on the average every three days. He distinctly smelt gas at the manhole nearest those where the explosion occurred on Sunday, December 30th, and on the Monday Mr. Gunyon, the engineer to the London County Council, and the electrical inspector of that body, agreed with him that there was a smell of gas at another manhole. He considered the leak detectors employed by the gas company useless, because they had failed to show the presence of gas in the manholes when he knew there was gas there. He made reports verbally and in writing to the gas company when gas was found in the culverts or manholes, but no acknowledgment was ever sent by the company of the receipt of his letters, nor did he learn, except indirectly, what took place upon them. He had made insulation tests of the particular section of main, and found the resistance of the positive to earth to be 1,740 ohms, and the neutral to earth 110 ohms, and the negative 330 ohms. On the feeder main, a shorter length, the resistances were:—positive 1,600 ohms, neutral 1,400, negative 4,500. On December 31st he tested the section between the manhole preceding those at which the explosions occurred, and the further of the latter two, and found a resistance of 10,000 ohms. The first tests he thought showed a very low insulation resistance; 10,000 ohms to 15,000 ohms would be a fair average test for mains that had been in use for two or three years. The insulation resistance varied greatly according to the condition of the atmosphere. Anything less than 1,000 ohms he should regard as faulty.

Mr. Bassett Hopkins: Have you not found as low as 200 ohms?

Witness: Yes, on the occasion of the explosion in Endsleigh Gardens a year ago.

Mr. Bassett Hopkins: Can you differentiate how much of the defective insulation is due to the mains and how much to the customers' work?

Witness: No; we should have to cut off all the customers to find that out.

Mr. Foulger: Do you expect to make a culvert gas-tight with concrete?

Witness: It is faced with cement as well.

Mr. Foulger: Do you know that water will pass through concrete?

Witness: Yes.

By Prof. Robinson: If the smell of gas was from the main, and not from an escape, he should expect it to be constant, but it was not so in this case.

Edward Bennion, electrical jointer in the Vestry's employ, said he found the fuses in the manhole all right immediately after the explosion. He saw the gas company's inspector apply the leak detector at one of the manholes where there was a smell of gas, but the indicator did not move.

Mr. W. N. Blair, A.I.C.E., engineer to the St. Pancras Vestry, said he made an examination of the sewer near the scene of the explosion, on January 4th, having seen a suggestion that it was caused by sewer gas. The air in the sewer was unusually free from smell, and there was no trace of coal gas. He had never heard of an explosion of sewer gas, which was not an explosive compound; but he had known of explosions of coal gas in sewers.

Mr. G. F. L. Foulger, engineer to the Gas Light and Coke Company, said the company denied that in this case the explosions were caused by coal gas, because the tests made had failed to denote its presence anywhere near the culvert.

By Prof. Robinson: The explosion last year in Endsleigh Gardens was undoubtedly caused by an accumulation of coal gas, and they found a leak in the vicinity.

By Major Cardew: The gas pipes in that neighbourhood were not old ones. His theory of the explosions was that hydrogen gas was formed by dampness in the culvert, and that this passed into the manhole and was arrested by the iron cover; thence it was diffused, and an explosive mixture was formed with the air throughout the whole of the box, this being fired by an electric spark.

Prof. Robinson: But we have it stated that the manholes were quite dry.

Witness: That may be, but we are dealing with the whole length of the culvert, and the moisture from condensation might cause the formation of hydrogen gas in small quantities.

Major Cardew: But if this had been the case to any extent, there must have been corrosion.

Witness: Exactly so; and we have no evidence of the culverts having been opened to prove that there was or was not corrosion.

Prof. Robinson said in view of the fact that there undoubtedly was a considerable invasion of gas, whether that was the fault of the gas company or not, he had advised the Vestry to carry out a more thorough system of ventilation, and his report was now under the consideration of the committee which dealt with the subject. Whatever recommendations were made to the Vestry, he was sure would be carried out with a view to the interests of the public.

Major Cardew: Do you consider that, by the adoption of the system of ventilation you now propose, all danger of explosion will be removed?

Prof. Robinson: I am quite confident it will prevent the accumulation of gas in the culverts. I cannot answer for the gas company that they will remedy their defective mains.

Major Cardew: It is the duty of the Vestry to protect their culverts and manholes from the accumulation of gas and water. Until they do so they are not complying with the regulations.

The inquiry then terminated.

NEW PATENTS—1894.

30. "Improvements in gear-wheels for electromotors and applicable to other purposes." J. C. QUINN and R. MCDOUGALL. Dated January 1st.

42. "Improvements in and connected with telephonic apparatus as adapted to mining and other purposes." M. BINSWANGER. Dated January 1st.

47. "An improved dial for ships' telegraphs and the like." W. H. BRODRICK and J. L. BANKS. Dated January 1st.

52. "Improvements in electric-lighting apparatus for railway cars." W. BIDDLE. Dated January 1st.

56. "Improved electrical cut-out." SIEMENS BROS. & Co., LIMITED. (Communicated by Messrs. Siemens & Halske, Germany.) Dated January 1st. (*Complete.*)

57. "A method of ascertaining the difference of electric potential at a distant extremity of conductors." J. HOPKINSON. Dated January 1st.

60. "An improvement in electric arc lamps." W. STEVENS. Dated January 1st.

65. "Improvements in dynamo brushes." THE LONDON ELECTRIC WIRE COMPANY, LIMITED, and J. WILLEY. Dated January 1st.

82. "Improvements in and relating to electric winding-mechanism for clocks." C. ARNOLD. Dated January 1st.

106. "Improvements in primary batteries." E. M. LEVETUS, H. LEVETUS, and W. ROWBOTHAM. Dated January 2nd.

107. "Improvements in primary batteries." E. M. LEVETUS, H. LEVETUS, and W. ROWBOTHAM. Dated January 2nd.

148. "Improved methods and apparatus for measuring electrical currents." O. B. SHALLENBERGER. Dated January 2nd.

157. "Improvements relating to telephone call stations with automatic charge or fee-receiving devices." C. A. JENSEN. (Communicated by N. Jacobsen, Norway.) Dated January 2nd. (*Complete.*)

176. "Improvements in connection with arc lamps more particularly adapted for electric searchlights." F. M. LEWIS. Dated January 3rd.

178. "Improvements in the manufacture of shades and shade frames for oil, gas, electric, and other lamps." H. BRITTAIN and S. H. BRITTAIN. Dated January 3rd.

185. "Improvements in telephonic apparatus for simultaneous telegraphy and telephony on the same line-wire." G. H. BASSANO. Dated January 3rd.

226. "Improvements in electric call and alarm apparatus." E. HERZ and J. P. HARTFUSS. Dated January 3rd.

230. "An improved automatic cut-out for electric circuits." W. KINGSLAND. Dated January 4th.

231. "Improvements in primary batteries." E. M. LEVETUS, H. LEVETUS, and W. ROWBOTHAM. Dated January 4th.

238. "Improvements in fittings for electric lamps." A. DENNY and A. C. CORMACK. Dated January 4th.

240. "Improvements in decorating gas chandeliers, electroliers, hall lanterns, brackets, table, hanging, and floor lamps for oil." C. MEASON and T. FORD. Dated January 4th.

261. "An improved electric stamper battery for ore crushing." F. HODGE. (Communicated by C. Evenson, New Zealand.) Dated January 4th.

281. "Improvements in and connected with telephones." H. OPPENHEIMER. Dated January 4th.

285. "Improvements in holders for electric incandescent lamps." T. COAD. Dated January 4th.

286. "Improvements in turbines and jet nozzles therefor." C. F. DE KIERZKOWSKI-STEUART. Dated January 4th.

297. "Improvements in the electrolytic treatment of tin and its separation from alloys and mechanical mixtures." C. F. CLAUS, jun., and H. S. SUTTON. Dated January 4th.

298. "Improved means for supplying an electrical current and safety devices for use in combination therewith with electric tram and other cars or vehicles." J. CLARET and O. VUILLEUMIER. Dated January 4th.

348. "Improvements in rectifiers for electrical currents." W. B. CLOSE. Dated January 5th. (*Complete.*)

351. "Improvements in electric arc lamps." J. E. A. GWYNNE and R. KENNEDY. Dated January 5th.

357. "An improved street, road, or underground junction box for electric conductors." J. T. ROSSITER. Dated January 5th.

358. "Improvements in electrodes for secondary batteries." J. WERSHOVEN. Dated January 5th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1894.

3,658. "Improvement in dynamo-electric machines." C. J. HALL. Dated February 20th. Claims:—1. In a dynamo machine, having a system of electro-magnets arranged radially in or on a revolving ring, a device for keeping the magnet windings in their places, which consists of a series of plates held with their edges in parallel grooves formed in the magnet cores near the poles of the same, and retaining strips or sheets facing the magnet windings along the edges of the same, the said strips or sheets being provided with internal flaps or flanges, and connected with the said plates by bolts, substantially as described. 2. In a dynamo machine having a system of electro-magnets arranged radially on a revolving ring, the combination of a series of sliding plates held with their edges in parallel grooves formed in the magnet cores, with means for preventing the axial shifting of the said plates, substantially as described.

3,749. "Improvements in galvanic batteries." A. J. BOULT. (A communication from C. Cudell, I. Cudell, and M. Cudell, all of Aix-la-Chapelle.) Dated February 21st. Claim:—A durable and easily renewable galvanic cell or element that admits of being hermetically sealed for use with charges of all kinds, whereof the one electrode is not liable to waste away in use, and, with or without a protecting and insulating casing, serves as a receptacle or cell to contain together with the materials of the charge, the second electrode which is liable to waste away in use but admits of being renewed. The whole substantially as described and illustrated in the drawings.

3,962. "Improvements in electrical switches." C. M. DORMAN and R. A. SMITH. Dated February 24th. Consists principally in an improved disposition of the insulating substance which enables the contact lever to be made entirely of metal, and, consequently, of a better and more durable design, and also enables the use of an improved form of spring to hold the contact lever in the "off" position. 4 claims.

3,986. "Improvements in electric motors." W. P. THOMPSON. (Communicated by the Ries Electric Specialty Company, of Baltimore.) Dated February 24th. Consists in the employment of two or more sets of subdivided field and armature magnets arranged to form substantially closed magnetic circuits of exceedingly short length; by so arranging the field and armature magnets that they have the relation of a divided or two-part transformer or transformers, in the preferred type of which, however, the windings of the two parts are connected in series, the moving portions of these divided magnets being rotated under the action of two or more progressively shifting fields, in such manner as to simultaneously exert the rotating effort at different circumferential points; by so winding and locating the subdivided magnets that their energising coils are in such inductive relation to each other as to neutralise or counteract the self-induction of the coils, thereby allowing a practically unrestricted flow of current and permitting the generation of an exceedingly intense magnetic field, by distributing the magnet windings over a large number of independent laminated cores of comparatively small cross-section instead of winding them upon a few massive cores of large cross-section; and lastly by practically eliminating the losses due to hysteresis and eddy-currents in the iron by maintaining the iron of the field and armature magnets, or a portion thereof, in a continuous state of stress or magnetic neutrality, and thereby transferring the energy that would thus be wasted into useful work in the coils of the motor. 26 claims.

4,987. "An improvement in arc electric lamps." E. C. DE SEGUNDO. Dated March 9th. Claim:—A glass enclosing the arc of an electric lamp, shaped and supported substantially as described with reference to the drawing, and for the purposes set forth.

5,025. "Improvements in electric rail or tramway systems." M. H. SMITH. Dated March 10th. The inventor provides an improved collecting device travelling on one side of the car and between the wheels of same, and provided with means for enabling it to pass laterally across the car underneath same with the object of enabling said collecting device to change sides when the car passes from one track to another, the combined rail and channel of which is on the opposite side to that in the other track. By this means a double channel on the lengths of single line is avoided, and the arrangement also avoids the coincidence of rail and channel points permitting fine points for the ordinary rails, thus securing smooth running, and quick points for the channel, giving strength. 8 claims.

5,118. "Improvements in and connected with electro-locomotion on railways." W. E. HEYS. (Communicated from abroad by J. J. Heilmann, of Paris.) Dated March 12th. The object of the invention is to permit the engine to work economically with a constant cut-off under the most favourable conditions, or, in other words, so that the work done is always proportional to the speed of the engine irrespective of the speed of the electro-locomotive and its train. A further object is to enable the driving engine to be started when it has stopped upon a dead centre. 3 claims.

5,243. "Improvements in electric perforating pens." A. D. LEWIS. Dated March 13th. Has for its object to provide certain improvements in electric perforating pens employed for perforating and indenting the writing material being written upon, such as drafts, checks, and other commercial paper, whereby alterations and erasures cannot be made without detection. 8 claims.

5,271. "Improvements in or connected with electric railways." E. H. BROWN. Dated March 13th. Relates to closed conduit electric railways of that type in which magnetic induction from the car is employed to lift the service conductor, and to switch surface supplies into and out of circuit with the main supply. 6 claims.

5,273. "Improvements in the conduit system of electric railways." R. W. BARKER. (Communicated from abroad by the Lawrence Electric Company, of New York.) Dated March 13th. Consists first, in forming the working conductor or main feed wire in sections, the said sections having suitable insulated material between them to prevent the electric current from running from one section into the adjacent section; second, in supplying the said sections with electricity from a continuous live wire which is insulated and encased within a suitable tubing, or its equivalent; and third, in conveying the electricity from the said live wire into a suitable cut-out box from which it is delivered to the auxiliary wire as the car passes over the different sections. 2 claims.